DISCOVERY

A Monthly Popular Journal of Knowledge

Vol. XIII. No. 152. AUGUST, 1932. PRICE 1s. NET

NEW EXCAVATIONS AT ATHENS.
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Notes of the Month.

The recent discussion in *The Times* on the nature of the Universe created considerable interest, and the correspondence included letters from many leading scientists. The chief point of the discussion was: What exactly does the scientist mean by saying that space-time is spherical and expanding? This complex problem inevitably involved technicalities, and soon became quite unintelligible to the ordinary reader. We have therefore invited Dr. A. S. Russell to summarize the discussion in less specialized language. Dr. Russell points out that the sphericity of the universe implies that if we were to travel eternally, we could not possibly eternally traverse new regions; we should be bound to retrace old paths, because in fact the amount of space is measured by a finite volume. If, says Dr. Russell, the layman does not believe a word of this there is no answer to him! But if he rashly affirms anything else the scientist will have no difficulty in citing experimental work which demonstrates that what the layman *does* believe is much more complex and much less true than the spherical universe!

* * * * *

The next point is this: it is now commonly held that the universe, in addition to being finite and unbounded, is expanding. The observed fact, of which there is no doubt, is that the spectral lines in the light which reaches us from bodies at great distances are displaced towards the red; their red light is redder than it should be. (Some of this light has taken millions of years to reach the earth.) The only interpretation of this, consistent with the laws of nature in a homogeneous universe, is a receding velocity of the body emitting the light. All the nebulae appear to be receding from the earth; the further they are from us the more rapidly do they recede. That is why the scientist says the whole universe is expanding. Whether the universe was originally small and static, and then, after a time, began to expand, or whether it has been expanding literally from the year one, is a point not yet decided.

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The discovery for the first time in this country of a minute crustacean hitherto only recorded in central Europe is a noteworthy addition to the list of British animals. The finding of *Bathynella* by Mr. A. G. Lowndes, of Marlborough College, has been briefly announced in *The Times*, and Mr. Lowndes will himself contribute a full account of his find to *Discovery* next month. Among the members of the subterranean fauna the crustacea play a prominent part. Like most of the members they are closely related to species still living in the surface waters in this country. There is, therefore, every reason to suppose that these species have been derived from surface-living forms at a time not very remote in geological history. When *Bathynella* was first found half a century ago, in a well in the city of Prague, its discoverer was quite unable to find a place for it in any of the recognized groups of crustacea. It was not until some eighteen years later, when the "mountain shrimp" *Anaspides* had been found in streams near the summit of Mount Wellington, in Tasmania, that it became evident that both *Anaspides* and *Bathynella* were survivors of a small group of primitive crustacea, the Syncarida, previously known as fossils from the carboniferous rocks of Europe and America. For more than thirty years after its first discovery *Bathynella* was not seen again.

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The excavation of Antioch by an international expedition under the auspices of Princeton University has proceeded for only a few months, but the

importance of the work being done there is already evident. One of the recent finds, the mosaic floor of a picture gallery dating from the second century A.D., has been described by Professor C. Morey as a discovery " of major archaeological and artistic importance." The floor, apart from its fine artistry, is regarded as highly significant, because it is the first evidence of the extension to Syria, as well as to Italy, of the " Alexandrian style " of painting. Professor Morey points out that this style " closely approximates to nineteenth century style in its freedom of movement, its idyllic quality, and its love of landscape." The mosaic was beneath a bathing establishment of later date—probably fourth or fifth century. The latter building was one of the first discoveries of the expedition, which began preliminary digging in March. One of the walls of the baths was placed across the mosaic, destroying part of it. Professor Morey does not believe the floor was used for ordinary purposes, but more as a picture gallery, couches being placed along the edges where guests could view the work of art. It is hoped that Professor Morey will contribute an account of the work to *Discovery*.

* * * * *

As announced in the Press, the Cunard liner *Scythia* has completed a trip to New York and back, during which one of the boilers has been fired with a liquid mixture of 60 parts of fuel oil and 40 parts of pulverized coal. The coal was prevented from separating from the oil by the addition of a " stabilizer." The coal-oil mixture was burned in the same manner as the oil with which the other boilers were fired, and no difficulty was experienced in handling it, nor was it found that trouble arose from the formation of ash in the furnace or from the emission of dust from the smoke stacks. The principle is not a new one, and from the technical standpoint has for long been a practical proposition. But no arrangements have been made to manufacture the coal-oil fuel in quantity, and to supply it to ships for bunkering. The matter is of very considerable importance, but unless a scheme were promoted by a group having coal, oil and shipping interests, difficulties in the way of success might prove to be considerable.

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The use of X-rays in anthropology is not new; the Piltdown skull was X-rayed at an early date, and radiograms of the latest discoveries in China have already been seen in this country. Curiously enough, however, excavators have always laboriously cleaned their specimens before submitting them to the X-ray, and it has remained for Mr. A. P. Bertwistle, in an article in the *British Journal of Radiology*, to point out the enormous saving of labour and damage that can be effected by applying X-rays to fossil specimen in the rough. Most anthropologists must often have spent hours of toil removing piece by piece the clay or rock from a lump in their hands, only to find that there was no specimen of interest at its heart, or else have suffered the disappointment of seeing the instrument slip and fracture the specimen it was hoped to preserve ! In future, the field-worker can not only tell in a few moments whether there is anything worth preserving in the mass, but also he can obtain a good deal of information—perhaps all he really needs—from the X-ray picture alone. The soil in which the fossil of the bone is embedded need not necessarily be of a lower density than the bone; if it is soft the bone will appear as a darker shadow, but in a hard limestone rock the bone shows up quite satisfactorily as a light area. Mr. Bertwistle's demonstration should prove of the greatest possible value to anthropologists.

* * * * *

The discovery in Java of what is claimed to be a new type of early man is announced by members of the Dutch Geological Survey. This is to be called " Solo Man " from the name of the river in the Pleistocene gravels of which the skull was found. It is similar to Neanderthal, but is distinct from that type, and is claimed to be more directly ancestral to the modern Australian than any other early type yet known. This discovery has been followed by a communication in *Nature* from Professor E. Dubois, the discoverer of *Pithecanthropus erectus*. In this he argues for the affinity of Solo Man with the Wadjak skulls, brought to light by himself in Java in 1889-1890 but not described until long after. He points out resemblances to Rhodesian Man, thus bringing the latter into the line of descent of the modern Australian.

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The total eclipse of the sun on August 31st is to be photographed near Montreal by a party of observers from the Solar Physics Observatory at Cambridge. The expedition recently set out for Canada under the leadership of Professor F. J. M. Stratton of Cambridge and Professor J. A. Carroll of Aberdeen, and carries nearly thirty tons of equipment. A special camera has been constructed for the purpose of observing the solar corona. The eclipse lasts for barely a hundred seconds, but it is hoped to take two photographs, about ten seconds being allowed for changing the plates. The expedition is financed by the Government Grants Committee of the Royal Astronomical Society.

The Secrets of Ancient Greece.

By Stanley Casson.

Every year brings discoveries of the first importance in the archaeology of Greece. The spade is as active as ever this year. Mr. Casson has just returned from a visit and here reviews some of the outstanding excavations in progress.

THERE is little sign of decreasing activity in the excavations now being carried out in Greece, nor is there the smallest likelihood that there will not survive enough sites to satisfy excavators for many years. The most important of the excavations recently begun is that at Troy. Here an American expedition has commenced work on the remains of the citadel of Troy which was left unexcavated by Schliemann and Doerpfeld. These excavations are in their preliminary stage and have been in progress for only about two months; it would therefore be inadvisable to expect any important conclusions at this stage. But what there is to be done at Troy is exceedingly important. Schliemann's excavations took place nearly fifty years ago when our knowledge of prehistoric Greece was so slight as to be negligible. What Schliemann did was done with an accuracy of observation and record which might well serve as an example to all subsequent excavators.

Doerpfeld finished what Schliemann had begun. But what was done by both was in fact only a small portion of an immense task. Only the citadel of Troy was excavated, and because of this it was thought that Troy itself consisted of this narrow circuit of walls and nothing else. But outside these walls there must be the suburbs of the city from which the inhabitants fled to the citadel in case of need. These suburbs must lie either on the flat ground below the hill of the citadel or else on the low hills of the scarp that bounds the city on the east. In addition there may be found the tombs of the Trojan kings and commoners. This would indeed be a discovery, since the character of Trojan tombs may help to provide a clue to the character of the tombs of the Minoan and Mycenaean world. At present we are entirely in the dark as to the origin at least of the great tombs of Mycenae. Neither their date nor the origin of their peculiar type is known.

Even in the citadel itself a great deal remains to be done. Fortunately Schliemann and Doerpfeld left unexcavated an area of ground which covers about a third of the Homeric sixth city and about an eighth of the earlier second city of Troy. A vast stretch of wall remains to be found and, above all, the new excavators will be able to establish the stratification of all the eight habitation levels from this surviving unexcavated area. This is their first and, in some respects, their most important task and it is this upon which they are now engaged.

The Mycenaean world of the Argolid has had new light recently thrown upon it by the admirable publication, long awaited, of the Swedish excavations in the royal tomb of Mideia. Now at last we have all the facts, and those facts are of supreme interest. The great tholos-tomb at Mideia was found to contain its burials intact. A comparison with the tholos tombs of Mycenae is at once suggested. Mideia was a small princedom, apparently independent but obviously wealthy and important. In this tomb were found the bodies of a king, a queen and a princess. The wealth of gold and silver ornaments found in the graves make the discovery most certainly the most important Mycenaean find since Schliemann opened the Shaft Graves of Mycenae. It would be superfluous here to repeat the long list of the beautiful objects found, but it was evident that the finest gold-work of Crete had survived at this small princely court and that the burials were in substance closely similar to the burials in the Shaft Graves, though nearly two centuries later in date. At any rate we now know what a tholos tomb looked like when its burials were intact within it.

FRAGMENT OF THE ATHENA.

The lower part of the figure of Athena from the west pediment of the Parthenon. This is among the most important of the recent discoveries described in this article.

THE EXCAVATION OF TROY.

A view taken from the ramp leading into the second city. In the background are the unexcavated parts upon which work has begun.

Some curious minor facts have emerged as a result of the close study of the finds. A group of strange finger-rings were found made of beaten layers of silver, lead, copper and iron. In addition to the important fact that we have here an early instance of the use of iron as a precious metal, or at least as a metal that was rare and significant, it is worthy of note that they may have been magic rings and the magic may well have lain in the association of lead, copper and iron which can, as is well enough known, generate a slight electric current. One is reminded of the odd "Rheumatism rings," similarly composed, which were sold far and wide not so very many years ago in England. The leaden horns of a warrior's helmet constituted another unusual find.

But other tombs were opened as well as the great Royal Tomb. And among the minor tombs, hewn in the rock, was one which was clearly a cenotaph to some person or persons who had perished abroad. The funeral objects were there, but neither bodies nor ashes. The date of this odd cenotaph is about 1200 B.C., and the excavators suggest tentatively that this is the cenotaph of two (for the funeral objects presume this number of dead) of the northern folk, perhaps the Danauna who may perhaps be identified with folk of these parts, who perished in one of the famous raids on the Delta of Egypt which are so faithfully recorded in Egyptian monuments of the period.

For the rest, there is no fresh news from other prehistoric centres. The Italian excavations at Lemnos still continue, but nothing further has yet been found to illustrate the partly Etruscan character of the Lemnians of the sixth and seventh century which is now assumed from a study of the recent finds.

The most promising researches in later periods are now taking place in Athens itself. The American excavations in the Agora, near the Theseium, are continuing steadily and have produced much valuable material. But it must be remembered that the undertaking is a large one and that many years must elapse before even a moderately large area is cleared. The recent discovery of a fine statue in the style of the late fifth or early fourth century B.C. shows that this region is full of promise. The absence of inscriptions of importance is at present the only disappointment. Recent work in the Agora has already been described in *Discovery* by Professor Shear, the director of excavations.

Of equal interest and promise is the excavation now being carried out by a private benefactor under the control of the archaeological authorities on the site of the Academy of Plato. Careful calculation enabled the excavators to find and clear several long stretches of the famous Street of Tombs that ran out from the city walls near the Dipylon Gate and ended at the Academy. True to its name, the roadway is lined with massive tombs of different periods. But the majority hitherto found seem to be of the sixth and fifth centuries B.C. The amount of pottery of the sixth century found in and round these tombs augurs well for the future discovery of sculptures or inscriptions of that age. There has already been found a fine statue basis with reliefs of mounted warriors on each of three sides, which belongs to the beginning of the fourth century. The original purpose of this basis is not clear, but it shows that the area under excavation is of great promise.

NEW TOMBS AT KERAMEIKOS.

In the Kerameikos cemetery at Athens numerous new graves have been found mostly of poor people of the third and second centuries.

Excavations in the Kerameikos cemetery are still in progress under the control of the German Institute. Here numerous new graves have been found, mostly of poor people of the third or second century. But their presence, undamaged, suggests that there is still much in the Kerameikos to be investigated. Most of the new tombs are surmounted, not with the elaborate reliefs of an earlier age but with the single monolithic pillar which became the standard Athenian gravestone after the sumptuary laws of Demetrius of Phalerum at the close of the fourth century, which forbade extravagance in funeral monuments.

The Parthenon is now improved beyond belief by the restoration of the north row of columns. The whole appearance of the Acropolis from near at hand or from a distance is enormously enhanced. The replacement of missing portions of marble with a fine concrete, toned to match the colour of the weathered marble of the building, was a wise decision. New marble would have made the restored portions so obvious as to appear a blemish. It is to be hoped that the south columns on which the work of restoration has now begun, will be repaired in the same careful and satisfactory way. With both sides restored, the building will have regained almost all its lost majesty, and will have the appearance that it bore before the fatal explosion of the siege of Morosini in the seventeenth century.

Archaeological contributions to the restoration of the Parthenon have been noteworthy. Last year the Director of the American School identified in a large fragment (which was on the Acropolis as the major part of one of the missing figures from the west pediment) a seated female figure of the same character

ATHENS FROM THE ACADEMY OF PLATO.

A view from the Academy showing the excavations in the foreground, near a house which must be demolished before furtner work can be done.

A VIEW OF THE AGORA.

The American excavations of the Agora are proceeding steadily and have already produced much of interest. The work will occupy many years.

as the " Fates " in the British Museum. It corresponds closely not only with a figure shown in the existing seventeenth century drawings of the pedimental sculptures, but also with a figure from a small-scale copy of a group of the Parthenon gable figures of the west pediment, made in Roman times and found at Eleusis many years ago.

This large and important fragment can be further decisively identified as Pheidian by its technique, which is identical with the admirable but unusual technique of the pedimental sculptures preserved in Athens and London. It is remarkable that this identification should have been made so late, since the fragment has been accessible to archaeologists for at least forty years. Now it is promoted from a place among the unconsidered oddments of the Acropolis to a position of honour in the Acropolis Museum, where its merits are at once evident.

The second fragment, similarly identified, is of the lower part of the figure of Athena, from the west pediment also. In a way this may be considered as the more important fragment, since it is from the principal figure of the temple. In the west pediment was depicted Athena and Poseidon, in the centre. The back of the helmeted head and the bust of Athena alone survive in the Acropolis Museum. Of Poseidon all that remains is the upper part of the body from the waist to the neck in two parts, of which one is in Athens and the other in London. The new fragment now gives us some idea of how to reconstruct the attitude of the Athena. From various sources it has been concluded that she was striding to her right away from Poseidon, holding in her horses. The new fragment shows that her stride was not quite so rapid or extended as had been assumed. Poseidon on the other hand, defeated in his contest with the

goddess, is rightly stepping back swiftly. Where so little, relatively speaking, of the sculptures of a great and famous building survive, the addition of even the smallest fragments is a matter of prime importance. And these are large and instructive additions.

That the Acropolis has by no means, even at this late date, released all its secrets, is clear from another interesting and surprising discovery made also by an American scholar, on the north slope of the Acropolis rock. Here there has for long been identified a cave of Apollo, with votive niches cut in the rock for the insertion of votive reliefs. A second shrine with similar niches is near at hand and has been long known, but its exact identity was uncertain. The new discovery consists of two inscriptions, both of the mid-fifth century, cut into the surface of the rock of the Acropolis. One gives only the name of Aphrodite; the other refers to "the Feast of Eros on the fourth day of the month of Munychion"—that is, in late April. Here is proof of the presence of a sanctuary of Eros and Aphrodite on the north slopes of the Acropolis rock. This in itself is a discovery of the greatest interest, but it has an additional value since it throws light on a very obscure matter.

Just above this sanctuary on the Acropolis was the house in which lived for the space of a year the two sacred maidens of Athens, whose duties were secret and who were involved at the close of their year of office in a series of ceremonies of which we are deliberately told very little by our ancient authorities. But we do know that the outgoing pair of maidens descended the Acropolis at night time by a private exit and passed into a sanctuary of Aphrodite. The only sanctuary of this goddess hitherto known is one near the temple of Zeus on the Ilissos banks. But this seems out of the way for the ceremony in question, and it is now clear that this sanctuary of Aphrodite, immediately below the dwelling place of the Arrhephoroi, the maidens of Athena, is exactly in the right position to suit the account of their movements. Thus another clue is given to this most mysterious of all the ceremonies which took place on the Acropolis. The fifth century has indeed been very fully documented by recent archaeological discovery.

A New British Expedition to Iceland.

PLANS for the Cambridge Iceland Expedition, which recently set out for the chief ice-cap, Vatnajökull, with the object of measuring its thickness by seismic methods, are outlined in the *Polar Record*. The expedition expected to land at Hornafjördr in Iceland and from there to ascend to Vatnajökull by way of the Heinabergs Glacier. Pony transport is to be used as far as the ice-cap; the ponies will then be sent back, and the party will proceed as two units, each of three men with a sledge.

The ice-cap will be crossed to the west end of Bruarjökull, seismic soundings being taken at selected points on the way. The soundings will be made by means of a geophysical seismograph. A similar method of sounding was used by the German Greenland Expedition, 1930-31, but this is the first time it has been employed by a British expedition. Briefly, the procedure is to fire a charge of explosive in the ice, at some distance from the instrument, which records accurately the instants of arrival, both of the direct wave travelling through the surface of the ice, and of the wave reflected from the underlying rock floor. The distance between the explosion and the recording instrument being known, the thickness of the ice can be calculated from the time interval between the reception of the two waves. Members of the party will later carry out a plane table survey of the northern border of Bruarjökull, which will be connected up on the west with the map of Kverknúka rani, and Kverfjöll compiled by Max Trautz in 1912. Observations will also be made on the glacial economy of Vatnajökull. The area provides features of special interest owing to the ice-cap being superimposed on a highly active volcanic region.

On reaching Kverkfjöll the second unit will separate from the survey party, and the geologists will make a survey and collect specimens. It is hoped to investigate the navigability of the river Jökulsa á Fjöllum with a view to a future expedition going down to the north coast in a folding boat. The object of this journey will be to study the disintegration of lava by an examination of the silts through the whole length of the river. Other work will include a search for the breeding grounds of the white-fronted and pink-footed geese, species which are supposed to be nesting at the sources of the rivers running northwards from the ice-cap. The botanical work will consist of a general ecological survey in relation to the birds, and seed dispersal between the oases of the Odadahraun. It will also include physiological experiments on the effect of a greatly reduced time of darkness. The results of these experiments will be worked out at Oxford, and will be the first adequate investigations of their kind.

Science and Industry—VI

Some Aspects of Fuel Research.

By Morris W. Travers, F.R.S.

In this country the fuel industry has not until recent years taken full advantage of scientific research. As Professor Travers shows, however, the results of work in the laboratory are now increasingly being applied in practice.

OVER a hundred years ago Faraday discovered the principle of electro-magnetic induction. During the following fifty years some of the best brains in the world were devoted to following up this discovery, and laying down the foundations of the science of electrical engineering. Almost every advance in the application of electricity to industry, or to the service of the public, has originated in the scientific study of a specific problem, by methods developed on purely scientific lines. Hence the soundness of electrical engineering enterprise.

Recent Progress.

Unfortunately the same observations cannot be applied to the subject of fuel technology. It is true that our metallurgical industries, particularly iron and steel, show a record of scientific research associated with industrial enterprise. But cheap fuel readily available did not stimulate scientific research in a country in which science has always been somewhat at a discount; and it is only quite recently that many of the most important applications of fuel have become the subject of scientific investigation. Meanwhile, progress has been actually impeded by the vast waste of money on enterprises initiated by the type of inventor who does not even know that the possibility or impossibility of operating any process is controlled by the laws of thermodynamics, which are absolutely rigid, and which can often be applied, by a properly trained fuel technologist, to determine beforehand whether a process is workable or not. Financiers and the public have only been too ready to back certain favourites, such as low temperature carbonization, often without knowing what a particular process aimed at; and many millions of money have been lost where the methods applied in the electrical industries might have led to success, and would certainly have prevented loss.

The word fuel used in this country certainly should mean coal, except perhaps in certain limited connexions. But what is coal? One would have expected this to be one of the first questions to arise, and one which would receive the closest attention. But it is one of the fundamental problems relating to fuel which has been neglected, and which has only of late received proper attention. Broadly, the investigation into the nature of coal has proceeded from three directions. In the first place the structure of coal in relation to its composition has been examined by methods which petrologists apply to the study of rocks, and an attempt has been made to classify coals on this basis. This work has been useful as a basis for further investigation. Secondly, the composition of coals in relation to their probable geophysical history has been the subject of much recent research. Thirdly, purely chemical methods have been used.

It is found that in any one coal seam the composition of the coal in different parts, and particularly at different depths, varies in such a manner that, if the oxygen content is plotted against the carbon content, the graph is practically a straight line. This rule is general; but for a number of different seams several straight lines are obtained which lie very nearly parallel. Moreover, all the straight lines so obtained lie very close to one another, so that for all coals the graph forms a narrow band as in Fig. 1. The inference is that all coals have a similar but not identical origin, and may have been subjected to slightly different treatment during deposition. Similar treatment during what may be termed the "coalification" process, depending on the depth to which the coal has been buried and consequently on the temperature and pressure to which it has been subjected, has had the same general effect on all coals.

This rule applies to the whole range of coals, from lignite or brown coal which has a high *oxygen carbon* ratio, through bituminous coals to anthracite coals, for which the *oxygen carbon* ratio is very small. It indicates that there is something much more definite about the character of coal than one would, perhaps, have thought, and forms an obvious basis for a scientific classification. We will now consider the more definitely chemical aspects of the coal problem.

Chemical Aspects.

Plant substance, which consists of woody materials described as cellulose and lignin, and the associated starch, sugars, etc., have a common chemical characteristic in that they are all built up to a great extent by the linking of carbon atoms in chains of six atoms, and to these chains are joined hydrogen and oxygen atoms. There are, of course, resinous

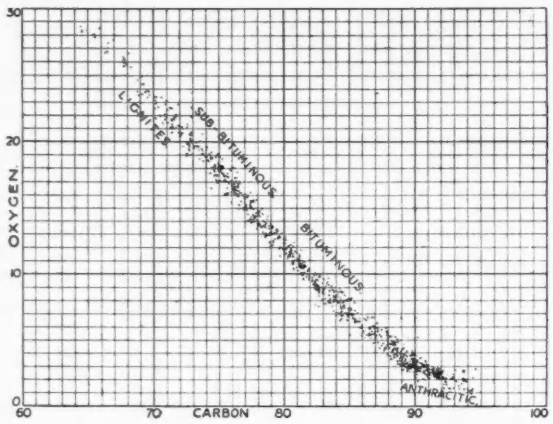


FIG. 1.

VARIATIONS IN THE COMPOSITION OF COAL.

and oily constituents of the plant, which after modification ultimately become incorporated in the coal substance, and account to some extent for the fact that the band in Fig. 1 is not a line. There is also reason to believe that the early changes during deposition involve loss of hydrogen, possibly owing to the formation of methane by a process of fermentation such as takes place when vegetable matter is destroyed in the septic tank of a sewage plant.

It seems to be quite clear, however, that the changes in composition during the coalification process, under the influence of pressure and heat, involve only the elimination of oxygen, partly as water and partly as carbon dioxide. A sugar, of the formula $C_6H_{12}O_6$, contains 40 per cent of oxygen and 53.3 per cent of carbon, so its position in the scheme shown in Fig. 1 would be off the picture to the left, and to bring it on to the picture would necessitate the removal of oxygen as water. Recent work, particularly that of Professor Bone, has shown that coal substance when submitted to certain chemical processes in the laboratory, and particularly to oxidation, yields products which are nearly related to benzene. Benzene derivatives are characterized by having six carbon atoms connected in the form of a ring, so we have at once an indication of the chemical nature of the coalification process. However, so far as we know at present, the changes during the coalification process proceed only to a half-way stage between most stable kind of carbon chain compound, and the most stable kind of ring compound, so that coal, on subsequent treatment, yields compounds of one type or of the other.

The problems of getting coal, and of cleaning, washing and air-blowing, etc., are outside the scope of this article. Processes to which coal is subjected come under two headings. The first is distillation, which includes coking for metallurgical purposes, retorting in gas works, low temperature carbonization, and hydrogenation. The second is combustion, which must include the preliminary stages of gasification in the gas producer, and pulverizing. Metallurgical processes come under the second heading.

In discussing any manufacturing process one must keep the object of it clearly in view. In the manufacture of metallurgical coke, which is commonly associated directly with the manufacture of iron, the main object is to produce a coke which is suitable for use in the blast furnace. The fundamental requirements of coke for this purpose are freedom from ash, and resistance to abrasion and crushing. Until recently it was supposed that what is called "combustibility" was an important factor. This may be measured by the rate at which the coke reacts with carbon dioxide in the furnace, reducing it to carbon dioxide.

As coke is heated, however, its combustibility diminishes, the carbon being converted more and more completely into crystalline graphite, and in an industrial furnace the temperature is so high that the combustibility of the coke is the same whatever the value for the original material charged into the furnace. Strength, the essential property, is secured by grinding the coal and, after washing, by blending coals having different coking properties. Thus a coke which would swell on carbonization, yielding a weak and porous coke (blended with a coke giving a dense but possibly a somewhat incoherent product) may be found to yield a satisfactory metallurgical coke. As many as three different coals are often blended.

While the object of the coke oven owner is to manufacture and sell coke, it is also to his interest to sell the by-products pitch, tar, oil, spirit, gas and ammonia. Ammonia is somewhat of a drug on the market, but it has to be got rid of. Benzene for motor spirit and oils are always saleable, but not always at a price pleasing to the manufacturer. The demand for pitch and tar varies. As the result of recent research, the surplus is being carbonized by running it into hot retorts, the products being more oil and spirit and a coke which is used for making electrodes for electro-metallurgical processes. The gas from coking plants is used for heating the coke ovens, but there is always a surplus, and this is sometimes used in steel works associated with the plants.

There is often a saleable balance of gas suited for towns' purposes, but sometimes there is a difficulty

in disposing of it. The City of Chicago is supplied by gas from the neighbouring steel plant, at a normal rate of one hundred million cubic feet a day. When a cold spell occurs the coking plants can supply no more gas, but water-gas plants are kept standing by, and the balance, up to nearly twice the normal demand, can be supplied as quickly as the demand arises, using coke, steam, and oil alone. In Great Britain difficulties have arisen due to the fact that coking plants are not commonly situated near towns, but not altogether inseparable from the fact that the distribution of gas is controlled by very conservative vested interests. The whole problem of utilizing coke oven gas, including the design and operation of stand-by plant, still requires investigation from the technical and economic standpoints.

The objects aimed at by the manufacturer of metallurgical coke are clear and definite. His problems relate to the cleaning and blending of coal, and to the technique of the coking process; the design and operation of coke ovens come under the latter heading. There is ample scope for research in all these directions. We now come to that branch of the carbonizing industries which deals primarily with the manufacture of gas. By no public utility service is the public better served in so far as the supply of gas is concerned than by the gas industry. The gas supply never fails. But while the industry has suffered from possibly excessive legal control and restrictions, it can hardly be claimed for it that it has taken full advantage of the possibilities of scientific research. There should to-day be no question as to the possibility of utilizing coke oven gas for towns' supply, or of supplying the domestic grate with a smokeless and reasonably dustless fuel. These problems should have been settled by an industry, almost every advance in which has been due to the enterprise of independent contracting firms.

It may be fairly stated that the aim of the gas industry has been to manufacture and distribute gas without particular attention to the quality of the coke made at the same time in regard to its use as a domestic fuel. The object of promoters of schemes for low temperature carbonization is generally rather less definite. It is usually stated to be either the production of a smokeless fuel for domestic consumption, or of oils which can replace fuel oil, or can be used for the manufacture of a motor spirit. Low temperature carbonization is commonly described as the process of carbonization carried out at temperatures under 700° C.

It is a curious fact that while this process of carbonization is one of the most important chemical processes carried out in this country, it has received but scant attention by chemists, but has generally been carried out in plants controlled by engineers. Attempts at research on carbonization has generally consisted in setting up experimental retorts, and distilling coal in them. The coal which went into the retorts, and the products which came out, were analysed, but it was rarely if ever that the sum of the quantities of carbon, hydrogen, oxygen, etc., which went in balanced the quantities removed. Attempts to balance the energy account were usually never supplied at all. What has been entirely overlooked, however, is that the chemical nature of the processes taking place in the retort has not been studied, with a view to understanding the process of distillation, and conducting it so as to yield the highest percentage of the most valuable products.

Further, before embarking on any investigation one should make some attempt to predict at least the general course which will be followed, by applying analysis based upon established theory. This process involves the use of chemical thermodynamics, a branch of chemistry which enables one to ascertain, not what is practically possible but what is fundamentally impossible. But even when we have ascertained by the application of thermodynamics that a certain process can take place at a certain temperature, it is by no means certain that it can be made

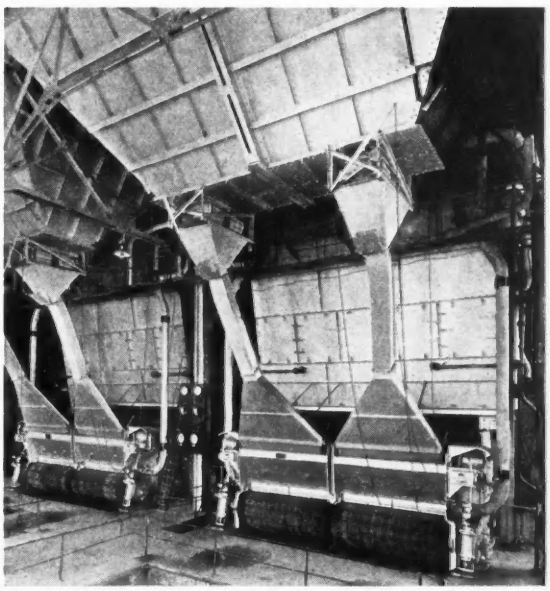


FIG. 2.

MECHANICAL STOKER.

An "Underfeed" chain grate stoker in a modern power generating station.

*

to take place fast enough to be commercially possible.

Our knowledge of thermodynamics suggests that coal should yield on distillation at temperatures below 500° a large proportion of compounds having a relatively large hydrogen content and related to the chain compounds. It also indicates that at higher temperatures the products will be ring compounds, related to benzene, together with free hydrogen, and methane. From the point of view of oil production low temperature carbonization should then be the more profitable, and carbonization of coal at low temperatures is also known to yield a solid fuel which burns more readily in the domestic grate than does the coke of the gas works. The main problem is really how to make the low temperature process go fast enough to be commercially successful. Some inventors try to get over the difficulty by carrying on the process at over 500°, thus defeating their own object. It is really partly a question of finding a suitable method of heating the coal, and partly a problem of finding suitable catalysts to hasten the chemical changes. This is perhaps not the usual view of the problems, but it is probably the correct one.

It has only recently been fully recognized that there are two very distinct stages in the process of burning fuel on a furnace grate, and as a matter of fact, the first complete investigation on the subject was published by the American Bureau of Mines about 1913. In the first stage the " primary air " or " bottom air " entering from beneath the fuel bed, after passing through a layer of ash, meets the incandescent coke, and immediately the oxygen disappears and is converted into carbon dioxide. This process is instantaneous, but as the carbon dioxide passes upwards through the incandescent coke a second and slower reaction takes place, in which the carbon dioxide takes up carbon forming carbon monoxide ; and this combustible gas, mixed with the nitrogen of the air, passes through the raw coal in the uppermost layer of the fuel bed, carbonizing it, and carrying into the furnace the volatile constituents. The fuel is not burned by the air which enters the bottom of the fuel bed, if the latter is more than four to six inches thick, and the fuel is evenly distributed, but only converted into combustible gas.

Chain Grate Stokers.

For many years past in large furnace installations using solid fuel, chain grate stokers have been used. These are bands made up of metal links. The fuel, as slack or small coal, is fed on to the band, which travels into and through the furnace, and as air is supplied from below, the fuel is gasified in the manner just described. However, towards the back of the furnace, where even the coke has been converted into carbon monoxide, and only the ash remains, there is a natural tendency for air to enter the furnace unchanged, and at a rate faster than through that part which is covered with fuel, on account of the resistance offered by the latter. In the older forms of chain grate stoking plant this actually happens, the air entering the forward part of the grate gasifying the fuel, and that entering the rear part passing into the furnace practically unchanged. The air and the combustible gas mixes in the furnace, and complete combustion takes place. But this is obviously an unsatisfactory arrangement.

Combustion of Gas.

In the modern chain grate stoker the air supply to different parts of the grate is controlled, so that there is a considerable air pressure maintained below that part of the grate which is covered by a deep layer of fresh fuel, and the pressure diminishes towards the back of the grate, where the fuel thins out. At the same time " top air," or " secondary air," is supplied above the grate so as to effect the combustion of the gas produced by the action of the primary air on the fuel as efficiently, from the point of view of transfer of the heat to the water tubes of the boiler, as possible.

At one time it looked as if the process of firing of large boiler units with pulverized fuel had come to replace the use of solid fuel on grates altogether. A great deal of research on the mechanism of the combustion of the minute particles of coal was carried out, and large scale experiments based upon the results of experimental and theoretical studies led in a few years to the development of the new process to a high state of efficiency. As far as large steam raising units on land are concerned, however, the new developments in connexion with mechanical stokers are tending to cause the pendulum to swing in the other direction. In the meantime the difficulties of utilizing pulverized fuel for firing marine boilers have been largely overcome.

But from the writer's observation it seems that a mistake has commonly been used in bunkering with dirty slack instead of with clean coal, which is false economy. The absolute cleanliness associated with the use of oil, added to the fact that in the oil-fired or oil-driven liner high-class labour can be employed in the stokehold, with the elimination of trouble whenever the ship leaves port, has made oil an ideal fuel for first-rate passenger vessels. But at the moment of writing it appears that important developments are being made in the use of oil and pulverized fuel.

New Light on the Siege of Oxford.

By R. B. Mowat.
Professor of History in the University of Bristol.

The part played by Oxford in the Civil War makes an account of the city during this period of more than local interest. Important light is thrown on the events of the Siege in a new book which is here discussed.

THE great Civil War of 1642-1646 was largely a middle-class affair, at any rate on the Parliamentary side. Success or failure in it depended chiefly upon the command of certain towns and ports; for on these depended inward and outward communications, and also direct and indirect taxes. The most important towns, for political and military reasons, were in the first place London, and next, Oxford, Bristol, Gloucester, Leicester, Portsmouth and Hull. If the King could have held or taken London, he would sooner or later have had the whole kingdom again. Driven out of London, he entrenched himself in Oxford, and kept there his court, parliament and military headquarters.

With Oxford as the centre, he planned to occupy and to hold round it a ring of little towns, villages and manor-houses, so as to command every road or bridge within a radius of ten or twelve miles. Therefore troops of Cavalier horse or foot garrisoned Bletchington House, Boarstall Castle, Brill, Abingdon, Wallingford, Islip, Woodstock, Eynsham. This made almost a perfect circle of defences, mostly within the ten-mile radius. A little further to the outside were the Blunts' house at Mapledurham, near Reading, and Stratton Audley, near Bicester, which also were held for the King. Any Parliamentary force marching towards Oxford, from north, south, east or west, would find the way blocked by a Royalist garrison holding market-town, village or manor-house, and with its little batteries planted at every ford or bridge. Such was King Charles' defensive system on the outer circumference of Oxford.

Defending the City.

In the centre, at the city itself, the King had a second and a more elaborate system. The old wall, even where it was still standing, was quite useless. The wall hugged the colleges and houses in which Charles, his court and his stores were; and if the enemy could come up to the wall they, or their guns, would be almost inside. Therefore, the immediate defences of the City and University were placed a little further away. Oxford itself, in the angle formed by the Cherwell and the Thames, stands on a spit of dry gravel, but all round is a watery vicinity, lush meadows with quiet streams often rising in flood. Thus, in the immediate vicinity of the city, Charles' engineers were able to make a splendid defensive system, comprising water-cuts, dykes and mounds. These can be made out from Loggan's pictures; many of them are still to be seen as you walk out towards Abingdon and Eynsham; and the undergraduate who has scrambled through a prickly hedge and trudged for half a mile through long grass may in the end find himself cut off from further progress by a channel, ten feet broad, of deep, motionless water.

The University.

On the Abingdon road, about a mile from Carfax (the conventional point from which distance is reckoned in Oxford) a cut from the Thames broke the roadway and was bridged and defended. Another cut was made nearer the city, with a sluice, so that Christ Church Meadow could be flooded. Mounds were thrown up for artillery. An embankment on what was later called Addison's Walk, at an angle of the Cherwell, was a Royalist artillery-emplacement.

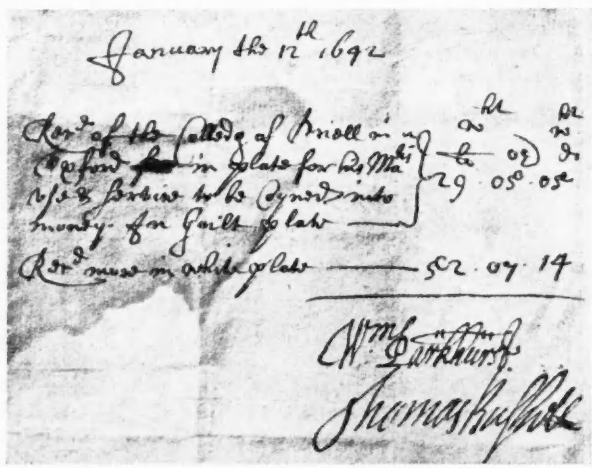
The University continued its existence in a curious half-academic, half-military way. The King lived in Christ Church and had his offices there. A door was made in the wall between Christ Church and Corpus; and a covered way was constructed through Corpus garden, so that Charles and his Queen could visit each other in all weathers. The Royalist Parliament (83 Lords, 175 Commons) was held in the old Schools near the Bodleian Library. The courtiers and the officers had rooms in the various colleges or put up with lodgings in the town. Some of the senior members of the University remained in residence; others went away to their people in the country. The junior members all remained. In the seventeenth century, although there were legal vacations, the bulk of the undergraduates never went home unless they lived near. They could stay all the year round if they liked. While the Civil War was going on, and while Charles and his men were in Oxford, the undergraduates combined reading and study with the practice of arms.

There was not very much lecturing at any time in the seventeenth century, and the undergraduates did not greatly miss it if the amount was reduced. Archbishop Laud, when Chancellor of the University, had ordained that every undergraduate should have

a tutor. The tutors took their duties seriously, as can be seen from *The Verney Letters*, but during the siege of Oxford their duties must have been somewhat relaxed. For, although the undergraduates were not pressed into the King's service, they did a good deal of drilling in companies. New College Cloister and Tower were used for an armoury and a magazine. Osney Mills supplied flour. Life went on with a military air, but there seems to have been no privation, although the Fellows of Oriel had to reduce their commons (or allowances of food) by one half in 1646.

Mr. Varley has written the annals of Oxford during the three and a half stirring years of Civil War. The book* is beautifully printed and illustrated. The author distinguishes three separate sieges of Oxford. The first, from May 27th to June 4th, 1644, was not a formal siege, but was an attempt on the part of the Parliamentary generals, Waller and Essex, to sieze Oxford, with the King in it, by a swift dash of their two armies. The second, which was a regular blockade and siege, was from May 21st to June 5th, 1645. The third was from April 14th to June 24th, 1646, when the garrison of the city surrendered.

The first siege has a tremendous element of drama in it, and would have concluded the war if it had ended successfully for the Parliament armies; for the King was in Oxford at the time and was caught between the "pincers" of Waller and Essex. These two generals had, with separate forces, passed through the ring of encircling Royalist country-houses and towns. On May 28th the Earl of Essex forded the Thames from the Berkshire side at Sandford, marched over Headington Hill and occupied Islip. On June 2nd Waller crossed the Thames at Newbridge, marched northwards and occupied Woodstock. He nearly surprised Charles, who was out hunting in that Royal manor. The King hastened back four miles to Wolvercote, where he slept the night in his coach, and went on early in the morning of June 3rd, for the remaining two miles, to Oxford.



RECEIPT FOR ORIEL COLLEGE PLATE.

According to a MS. in the Bodleian, 1,610 lbs. of plate were received at the Royal Mint on January 12th, 1642. This illustration is reproduced from "The Oriel Record."

A Council was hurriedly held. The opinion was expressed that the King was really caught, and that he had better surrender. He could not go out along the London Road, which was patrolled by Parliamentary troops; nor could he go out north-eastward into Northamptonshire, for the Earl of Essex held the Cherwell bridge at Islip; nor could he go due north to Warwickshire, because Waller held Woodstock. Charles, however, thought that, if he was to be taken, he might as well be captured while trying to escape, as by quietly surrendering. There was one avenue out of Oxford that possibly was open; this was north-westward by Wolvercote, Yarnton, Long Handborough into the Cotswold country. He would have to ford the Thames near Yarnton, and the Evenlode at Handborough.

On the evening of the same day as the decision was made, the King and Prince Charles his son, with sixty or seventy carriages, 2,500 musketeers and a body of horse, went out in the summer twilight along by Port Meadow to Yarnton, found the fords unguarded, passed over the Evenlode at Handborough, and so along the well-known road to Witney, Burford and to safety in Worcestershire. As Oxford without the King was not worth a long siege to the Parliamentary forces at this stage of the war, Waller and Essex made no further effort against the city.

The second siege of Oxford, 1645, was the result of the creation of the New Model Army, which, it was hoped, by vigorous operations on the grand scale, would bring the war to a speedy conclusion. Mr. Varley reproduces from the State Papers the list of siege-equipment ordered by Parliament: 2 demi cannons and three whole culverins, 1,200 spades and shovels, 500 pickaxes, 300 steel spades, 200 scaling ladders, 500 barrels of gunpowder, 40 tons of match, 30 tons of bullet, 300 great and 300 small grenade shells, 1,000 hand grenades, 20 carriages for provisions and 200 horse harness.

**The Siege of Oxford.* By Frederick J. VARLEY (Humphrey Milford, 7s. 6d.).

On May 21st, 1645, Fairfax completed the blockade of Oxford, so that "they can take in no further provisions." On May 22nd he entered Marston village and crossed the Cherwell there, and passed through what are now the University Parks and over Port Meadow to Godstow. A cannon-ball fired from Marston hit Christ Church Hall. On June 2nd, the besieged garrison made a sortie up Headington Hill, surprised the Parliament troops there, killed 50 and took 96 prisoners. Next day the siege was raised; and on June 5th the Parliament troops evacuated Wolvercote, Marston and Headington, and marched off to Aylesbury. On their way they tried to storm Boarstall Castle, which was held for the King. Boarstall is a moated country-house of no great size. The Parliament troops failed to take it. The Royalists re-occupied Abingdon, Dorchester, Woodstock and other little towns surrounding Oxford.

THE OXFORD CROWN-PIECE.

Although the personnel of the Royal Mint remained in London, several skilled engravers followed the King to Oxford, where the Oxford crown-piece was minted in 1644.

The King was not in Oxford during this second siege. He had an army in the field, in Worcestershire. This was the reason why Fairfax abandoned the second siege of Oxford when it looked like prolonging itself into the summer. He wrote to his father (June 4th, 1645): "I am very sorry we should spend our time unprofitably before a town while the King hath power to strengthen himself. The Parliament is sensible of this now, and therefore hath sent me directions to raise the siege and follow the King." Fairfax had the correct strategy. The King's army was sought out; battle was offered and accepted; and on June 14th the Royal Army was routed at Naseby in Leicestershire. After this disastrous and indeed fatal summer campaign of 1645, the King went into his winter quarters at Oxford. He remained there from November 5th, 1645, until April 27th, 1646, when he escaped through the besiegers' lines, and went away to surrender himself to the Scottish army.

Nothing of importance happened during the winter of 1645-46. On March 21st, Lord Astley, coming from the west with a small Royalist force to relieve Oxford, had been met and routed by Parliament troops at Stow-on-the-Wold. This defeat, the last battle of the Civil War, made the situation of Oxford hopeless.

The Parliament forces were now in Abingdon, on the Thames, six miles below Oxford city. On April 15th the besieged garrison heard the noise of Parliament artillery, which had opened fire against Woodstock Manor House, commanding the road northwards; on April 26th Woodstock Manor surrendered. Thus the Parliament troops held all the roads and all the bridges outside Oxford—the westward road through Burford and Stow; the northward road through Woodstock; the southward road through Abingdon, and, of course, the eastward road over Headington Hill to London. A Parliament battery on Headington Hill was discharging its cannon-balls into the heart of the City. No time must be lost if the King was not to be caught by the incoming troops—if, indeed, there was any chance of his escaping at all.

On April 27th the King, disguised as a groom, rode over Magdalen Bridge and gave the pass-word to the guard at the gate. At first he was heading straight for London, riding rapidly through Dorchester, Henley and Slough; then he turned north and by way of Hillingdon and Harrow, and Cromwell's own county of Huntingdon, he made his way to Newark where the Scottish Presbyterian army was camped.

Oxford was now doomed; but with the King away, the besiegers made no attempt to storm their way in. They could afford to wait. On May 8th Banbury Castle was captured by Parliament; on June 10th Boarstall Castle fell. Now all the roads were open to the besieging forces. On June 18th and 19th the surrender of Oxford was offered and accepted. The negotiations were carried on in the little village of Marston on the Cherwell, two miles out from the City, but the terms of surrender were signed in the Audit House of Christ Church. Three thousand of the King's soldiers were allowed to march freely, with the honours of war, away from the city which they had so steadfastly defended.

Mr. Varley reprints the complete articles of surrender. His book also contains two chapters which deal briefly but informingly with the question of College plate, and with the history of the Royal Mint at Oxford. When Parliament troops were in Oxford in September, 1642, before the battle of Edgehill,

the Governor or Commander (Lord Say) could have requisitioned all College plate; this plan, apparently, was deliberately considered and rejected. The King, on the other hand, had scarcely established his headquarters in Oxford, when he proceeded (January, 1643) to requisition plate for his Mint. All the Colleges, more or less willingly, surrendered their plate against Royal receipts and promissory notes, the King undertaking to repay at the rate of five shillings an ounce for white plate and five-and-sixpence for gilt.

Each College, however, was permitted to reserve certain articles (Founders' cups, chalices, mazer-bowls and such) which had especial religious, historical or artistic value. No satisfactory explanation has been found to account for the fact that some colleges, for example, Corpus, were able to reserve a much larger and finer selection of their plate than others. Concealment on so large a scale would appear to be impossible, and compounding in money was, so far as is known, not permitted by the King. The late Provost of Oriel, Dr. Shadwell, argued, with learning and ingenuity, that College plate had, in effect, suffered comparatively little from the King's requisition.

A Royal Mint was established at Oxford by proclamation of the King on December 15th, 1642. A staff of high craftsmanship was brought together, and beautiful coins were struck at New Inn Hall, where the Mint was placed; there were pieces of 20 shillings, 10 shillings, crowns, half-crowns, shillings, half-shillings, groats, quarter-shillings, half-groats and pennies, besides a three-pound gold piece and others. The three shilling piece coined in 1642 has completely disappeared.

We commend Mr. Varley's book to all who are interested in Oxford, as well as to those who take delight in the study of antiquities, especially when the antiquities bear on the broad questions of England's history.

Preserving Works of Art: A New Invention.

A NEW invention for the preservation of works of art is likely to supersede the laborious methods of restoration. The apparatus is the invention of Mr. S. Kennedy North, and is at present being used in the restoration of two famous Titians, "Diana and the Actaeon" and "Diana and the Callisto."

According to *The Times* the pictures are first of all completely reproduced in a series of X-ray photographs, covering the whole surface. The photographs, which distinguish broadly between the original and the present condition, are used as a guide. In the case of oil paintings the defects are chiefly, though not exclusively, in the coats of varnish successively applied, and the dirt accumulated upon their surfaces. The problem is to find a solvent which will remove the varnishes without disturbing the most delicate of the original glazes underneath. But before anything is done the pictures are thoroughly soaked in a solution of paraffin wax; a substance which is chemically and bacteriologically inert, and also has the valuable properties of slowing down the action of any solvent which may be applied, thus increasing control, and fortifying the original substances of the painting.

The solvent is a vapour, of a certain constitution, temperature and volume, applied in the apparatus. In form it is not unlike a gardener's cold frame, consisting of metal and asbestos sides and a glass top, with orifices for ventilation, appliances for regulating the temperature and the pressure, and an electric fan, revolving horizontally, to induce a regular circulation of the vapour. In this frame the picture—the two "Dianas" measure about 7 feet by 6 feet each—is placed face upwards, the glass top enabling the whole surface to be kept under observation. In order to prevent radiation the glass is covered with a blanket, removable in sections. The action of the vapour is to dissolve the binding constituent of the varnishes, leaving their other ingredients in the form of a non-adhesive resinous powder, or scurf. By careful calculation, and adjustment of temperature and pressure, it is possible to remove one coat of varnish at a time without disturbing the one beneath. The loose resinous powder is removed by carefully brushing with a solution of paraffin wax in a volatile liquid.

The effect of this method of conservation is not only to restore the picture to its original condition without the least injury to pigment, and to preserve it against future damage from time, insects and atmospheric influences, but also, by removing obscurities, to throw an entirely new light upon the qualities of the artist. Indeed, before Mr. Kennedy North began his work—first of all upon the "Venus Rising from the Sea," whose condition is now a revelation—our ideas of Titian's colouring, particularly as regards his blues, were completely mistaken. The two "Diana" pictures were painted about 1559 for Philip II of Spain. Philip IV, disliking their subjects, promised them to Charles I, but they were never delivered. In the eighteenth century they were in the collection of the Duke of Orleans, and they later came into the possession of the Bridgewater family.

The Scientists and the Universe.

By A. S. Russell, D.Sc.

Much interest has been aroused by the recent discussion in "The Times" on the nature of the Universe, in which leading scientists took part. As the correspondence became somewhat difficult for the layman to follow, we have invited Dr. Russell to summarize the discussion in more concise form for readers of DISCOVERY.

THE Universe has recently been the subject of two very different discussions. Last September it was discussed by the men of science at the British Association, principally with regard to its evolution; and the report of this discussion is in some ways one of the most remarkable things that has ever been printed. All the great men took part in it. Sir James Jeans led off. The Abbé Lemaître, who is largely responsible for the present view that the universe is expanding, followed. Sir Oliver Lodge summed up. Among those who took part were Professor de Sitter, Sir Arthur Eddington, Professor Milne and the Bishop of Birmingham.

"Space-time."

More recently, in May and June of this year, *The Times* has published a long correspondence on one particular point in the whole subject, namely, what does the scientist mean exactly by saying that space-time is spherical and expanding. The "common-sense" view of space was opposed to the rather strange view of the scientists. The discussion was started by Mr. Stephen Coleridge who as a layman was anxious to know what all these mystifying words were supposed to mean. Among those who joined in were astronomers, physicists, popular expositors, novelists, poets, essayists, philosophers, and, of course, laymen.

Apart from technicalities, the impressive thing about the first discussion was that men of science should be so unanimous about the stupendous and almost unimaginable facts concerning the universe on the physical side. There are now no "Euclideans," no "non-relativists." Einstein's general theory of relativity did away for ever with Euclidean space and gave us the present idea of a spherical universe. The old and "common-sense" idea that the universe stretches out everywhere to infinity is now quite dead; more than dead, in fact, it is damned. However simple this view might seem, the fact is that nobody believes in it longer. It was a pernicious view in that it kept back ideas which ought to have been let loose years ago. Another way of describing the spherical universe is to say that it is finite but unbounded. The layman often says he can imagine infinite space, but he cannot picture a space finite but unbounded. The scientist, instead of saying truthfully, "Neither can I," has gone out of his way by analogy and example to put into words what he pictures, often with the consequence that he has unnecessarily confused the layman.

All that is implied in the sphericity of the universe is that if we were to travel eternally we could not possibly eternally traverse new regions; we would be bound to retrace old paths, because in fact the amount of space is measured by a finite volume. If the layman says he does not believe a word of this there is no answer to him, but if he rashly affirms anything else the scientist will have no difficulty in citing experimental work which demonstrates that what he does believe is much more complex and much more untrue than the spherical universe.

The next point is this: it is now commonly held that the universe, in addition to being finite and unbounded, is expanding. The observed fact, of which there is no doubt, is that the spectral lines in the light which reaches us from bodies at great distances are displaced towards the red; their red light is redder than it should be. (Some of this light has taken millions of years to reach the earth.) The only interpretation of this, consistent with the laws of nature in a homogeneous universe, is a receding velocity of the body emitting the light. All the nebulae appear to be receding from the earth; the further they are from us the more rapidly do they recede. That is why the scientist says the whole universe is expanding. Whether the universe was originally small and static, and then, after a time, began to expand, or whether it has been expanding literally from the year one, is a point not yet decided.

Radius of the Universe.

Sir Arthur Eddington, however, has calculated that the original radius of the universe was comparatively small, a mere matter of about 1,068 million light years, a distance, in other words, which could be traversed by a ray of light, doing 186,000 miles to the second, in that number of years. It is calculated from experimental observations that after the universe began to expand its radius doubled itself in about every 1,300 million years. This period, at first sight large, is smaller than geological time and many have

felt this rate of expansion is alarmingly rapid, despite the fact that the great majority of mankind are blissfully ignorant of the whole moving process. The shortness of this period of 1,300 million years has an important consequence.

The Expanding Universe.

We are all familiar with the fact that if a number goes on doubling itself it reaches tremendous figures in a short time. Now the physicists have a good idea of the present diameter of their spherical universe, and they know how large the universe was before it began to expand. It is a simple calculation to find out how long it has taken the original universe to become the present one. It comes out that this time is only between a tenth and a hundredth of the time that has been assumed to be necessary for the evolution of the stars on present theories. The time for this, it is well known, is to be measured in millions of millions of years, but this time is much too long for the original small universe to have expanded into the present one. The rate of expansion is a matter of observation, and although observations are liable to be incorrect the general agreement of different observations has forced a dilemma upon the physicist. He must either abandon part of the theory of the expanding universe or he must very seriously curtail the time which he has hitherto imagined to be necessary for the general evolution of the universe. His inclination at the moment is to let the latter go hang.

Sir Arthur Eddington has recently found a correspondence between the characteristics of the universe and those of the electron. He finds that a certain term in the theory of electricity, attributed ordinarily to the mass of the electron, is nothing less than " the square root of the number of electrons in the universe divided by the radius of the universe in its equilibrium (that is, its original) state " ; and from this amazing identification he calculates the radius of the original universe which has been given above and also the rate of expansion which he finds well in accord with the mean of the experimental observations. From " the square root of the number of electrons " he finds that the number of protons (the units of mass) in the whole universe (literally everything, literally everywhere) comes out at the round figure of 129 followed by seventy-seven nothings. From this result it is a mere matter of slide-rule or logarithm tables to say how many times the whole universe is heavier than some familiar unit, say, the sun. The answer comes out at 108 followed by twenty nothings !

To me the amazing thing about these stupendous figures is not that they are accepted provisionally as the best that is at present known, but that they could ever be put forward at all. Instead of taking our place humbly on one of the smaller planets revolving round a quite tenth-rate sun, we have the impertinence to have views not only about our own planet or even solar system, but about the whole universe at large as God made it. We have the presumption to *assume* that the universe was made so that man might understand it, although we have the humility to say that this is by no means proved. It is, of course, finite. Infinite space, as Bishop Barnes said, is simply a scandal to human thought, and we have measured how far it is across. A " static " universe is probably also a scandal to human thought, and certainly it is " mathematically unstable " ; to be alive, in the sense that it can be alive, it must either contract or expand, and expand, as experimental evidence shows, is what it appears to do.

It is not to be wondered that these views, however confidently put forward by those with the best right to have opinions, have met criticism from outside ; it is marvellous, really, that they have escaped it for so long. The reason for this is, I think, that in the domain where all the big advances are at present being made—physics—emotions are not readily aroused. If you speak disrespectfully of the universe or the electron you are not seized by the police ; there is as yet no society with energetic officials to get on your track for maltreating the inorganic world. To those of us who attempt to follow modern physics it is very exciting and even ennobling to think that the universe in which we live is curved, finite, and probably expanding, but to the majority of our fellows it does not matter a blow. To them the wonderful thing is that they are alive in it at the present moment. Granted a universe, they would say (if they ever thought about it) it is no more remarkable that it expands than that it contracts or stays still. The scientists' views on the universe, therefore, are not likely to be the subject of animated letters to the editors of our newspapers.

Inside the Sphere.

Yet, as I said earlier, they have been. Correspondents wanted to know if space were a sphere what was inside the sphere. If it were expanding, what was it expanding into? Sir James Jeans, who was drawn into the discussion at the beginning, used the word " subjective," and the philosophers had, of course, to explain to him that this word has two meanings and generally to put him right. An expanding universe apparently presented no difficulty to the layman ; his difficulty was in imagining *space*

as spherical and expanding. The nature of real space, we were told by a philosopher, as distinct from "physical" or metrical space-time, is a metaphysical problem lying beyond the scope of scientific enquiry. Sir Oliver Lodge and Professor Herbert Dingle made illuminating replies to many of the difficulties put forward. It was an error, they pointed out, to think that the contrast between the traditional view of space and the expanding universe was a contrast between common-sense and mathematical abstraction. The scientists have unwittingly misled the layman in trying to make their abstractions imaginable. The layman has just been a little perverse in taking too literally an analogy invented with the best intentions for his own benefit. If we try to imagine the inside of the sphere which is space-time, or what it is expanding into, we are extending the analogy illegitimately to something which has no representative in the actual universe. "The idea that the sphere is expanding means that if we measure the volume of the sphere to-day and again to-morrow by approved accurate methods, we shall find to-morrow's result greater than to-day's; that is all." All attempts to imagine what the metaphorical sphere is expanding into are futile. Nobody can imagine that.

The advancing physicists, although they often appear uncommonly confident about their results and are undoubtedly extraordinarily clever people, are entirely distinterested. They are often precipitate in their conclusions and quite shameless at times in their agility in hopping from one view to another; but they break no bones. If the other side can put forward a better—a simpler and more self-consistent—view of the universe, if they can furnish a new theory which explains what is known, no worse than the old and better theory predicts phenomena afterwards found to happen, none would rejoice more than their opponents. The fact that they have got so far with their experiments and theories both in the great depths of space and in the deepest recesses of the atom is proof, if proof be needed, that we are living in a very great age.

X-Rays and Radium.

THE Royal Commission appointed in Ontario last year to investigate the use of radium and X-rays in the treatment of diseases in various centres throughout the world has just published its report. The Commission has investigated radiological centres in Canada, the United States, Great Britain, Germany, France, Belgium, Sweden and Denmark, and the report gives an account of the equipment found in these places, and of the opinions expressed by various experts. There is a valuable review of cancer research, and of the various schemes for educating the public about cancer and providing a social service organization.

In its conclusions the Commission reviews the present knowledge—or absence of knowledge—of the cause of cancer and emphasizes the deplorable delay in seeking advice. It feels an urgent need for a widespread campaign of education by every means until the public attitude of fear of cancer is replaced by fear of delay. Since cancer causes an enormous economic loss to a country, and since sickness is the greatest cause of poverty, all parties, municipalities and governments should co-operate in the prevention of disease. It is admitted that at present surgical measures hold the first place in the treatment of cancer as a whole, but radium and X-rays are even better for certain parts of the body, apart from their importance as palliative agents. The report stresses the danger of inadequate or unskilled radiotherapy and the necessity for specially-trained clinicians, like those in charge of treatment clinics in Sweden.

The Commission considers that the use of the radium bomb and of high-voltage X-radiation is worthy of further investigation. Various authorities are quoted in estimating the quantity of radium required by any country as 2 gm. per million of population, or 2 gm. for each 1,000 deaths from cancer. The report urges the establishment of radio-therapeutic centres associated with large general hospitals, and provision for hopeless cases apart from these centres. The centres should be provided with adequate laboratory facilities, including physics, chemistry, pathology and bio-chemistry, and the closest co-operation with all services which deal with cancer. The appointment of a Commission or a Commissioner is recommended to supervise the custody and distribution of radium, the organization and supervision of centres, and particularly the maintenance and close co-operation of all services. An active social service for every centre should keep tract of patients, bring them back for observation and re-treatment, supervise home conditions and provide moral and financial aid. The need of cancer research of all kinds is urged, and the Government is advised to investigate any method of treatment which gives reasonable promise. The conclusions and recommendations of this Commission will command the approval of almost all who are familiar with the problems it has considered.

New Research on Heredity.

New research by an American scientist on the "genes" in the cells of a species of lily promises to throw interesting new light on the nature of heredity. The genes have been counted and photographed for the first time, and the following is an account of the work just received from the Carnegie Institution of Washington.

A CENTURY ago, in attempting to explain the chemical behaviour of substances, scientists found it necessary to assume the existence of atoms. Similarly, in biology, the results obtained from experiments in breeding plants, insects and higher animals can be explained by assuming that genes, or units of heredity, actually exist, that they are located, as separable particles, at definite and constant places in the chromosomes, the "carriers" of heredity, and that the genes are responsible for hereditary traits which distinguish one species and one individual from another.

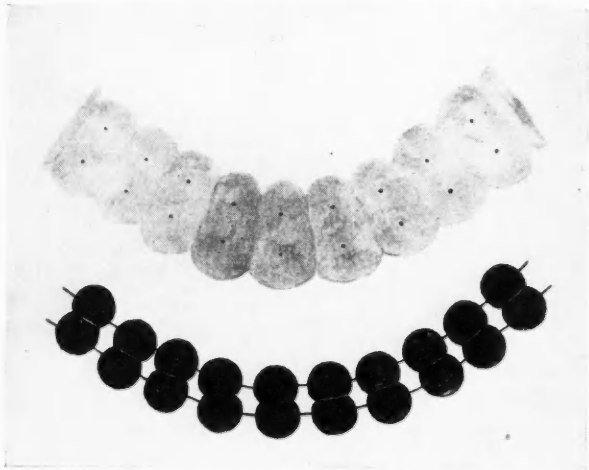
For some years Dr. John Belling, cytologist at the Carnegie Institution of Washington, has been engaged in research on the organism of inheritance believed to lie within the chromosomes which occur in the nucleus of living cells. The work has involved a study of the principles of optics as they apply to extremely high-power microscopes; a search for plants having chromosomes which could be studied to the best advantage; and the development of an improved technique in preparing chromosomes for observation. "We wonder, on the one hand," writes Dr. Belling, "at the great diversity of species; on the other, at the marvellous precision with which each species is reproduced. We marvel, also, at the wonderful fitness of organisms to the world in which they develop and, in turn, reproduce. It is for the geneticist to give a scientific explanation of these phenomena, to bring under general laws the isolated facts of development, of diversity, of fitness.

"The first great advance in the scientific explanation of these phenomena was the tracing of the development of the individual by embryologists. The next was the discovery of the mechanism by which the internal factors that control development do their work. It is because the germ plasm—the chromosomes and their constituent genes—shows a continuity that the species reproduces itself. It is the failure of the former germ plasm to continue to reproduce itself in the same way that is responsible for genetic variation or mutation. Yet this failure is regular; and the laws determining it are the subject of our investigation."

It was found that plants of the lily family were especially suited to research of this kind because the essential structures are more widely separated than in other plants. The Easter lily, the Madonna lily, the royal lily, and the leopard or tiger lily of California, were the members of this family which were most frequently examined; but it was in the last of these that Dr. Belling first observed the objects which he believes contain the genes.

Although, according to theory, genes are present in the tissue cells of plants and animals as well as in their germ cells, it is with the latter, more particularly the pollen mother-cells of the flower buds of the lily, that Dr. Belling works. He takes the anthers (pollen-bearing flower parts) when they have reached the proper stage of development, cuts them open and presses the mother-cells of the pollen out on to a clean glass slide which he instantly immerses in a fixing solution consisting of a combination of powerful chemical agents. It is important that the cells should be killed instantaneously; for if they are permitted to die slowly the structures which it is necessary to observe fuse and lose their distinctive appearance.

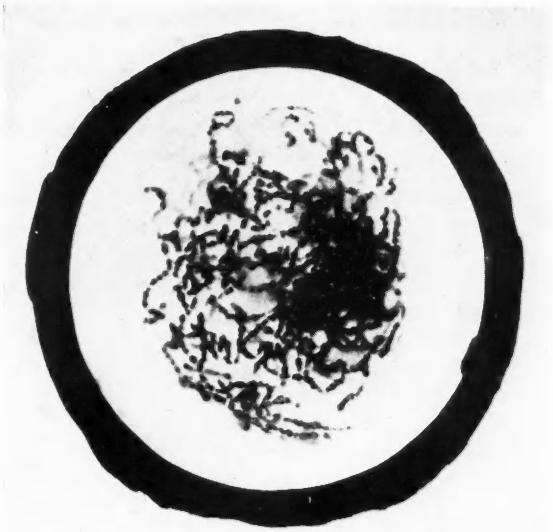
After the preliminary preparation, the slides are subjected to treatment with various staining solutions which the cell structures absorb in differing degrees, thereby making them more easily distinguishable



CHROMOMERES IN POLLEN MOTHER-CELLS.

(Above).—A double row of chromomeres in pollen mother-cells as seen through the microscope. The chromomeres have been squeezed and the minute gene is seen in each. (Below).—A drawing of the chromomeres before squeezing.

under the microscope. Although the cells are less than one four-hundredth of an inch in diameter, Dr. Belling has seen and counted at least 2,200 different bodies which he thinks are the ultimate units of inheritance. In the living plant a coat of stainable matter forms round the genes which is viscid in character and can be pulled into long strings. A gene with a coat of stainable matter is called a chromomere. Each of the strings of chromomeres, of which there are twenty-four in the tissue cells of the lily, constitutes a chromosome.



CHROMOMERE FORMATION.

One of Dr. Belling's photographs of chromomere "strings" in a single cell of the leopard lily. This new research is described in the text.

A minute cell sphere, with 2,200 gene pairs, suggests the celestial sphere visible to the naked eye and containing fewer than 3,000 stars which can be seen at one time. The stars were supposed by some to exert a mystic influence on human beings. In the spherical cells of the organism, however, the genes actually do exert specific influences on the life of the organism in question, whether of the lily or of man. In fact, the influences are so pronounced that if the effects of all the thousands of genes in a given organism were added together nearly the whole of its inheritance would be accounted for. The strings of chromomeres are of more consequence, therefore, than the threads of life which, according to legend, the Fates were reputed to spin. Dr. Belling suggests that if we could identify every one of the chromomeres in a man (probably there are many more than in a lily), a reliable horoscope could be drawn up.

There is, of course, a method of cell division common to practically all plants and animals which insures that all the cells of the individual except the reproductive cells shall carry the full number of chromosomes characteristic of the species; that the reproductive cells in each case shall contain one-half of the characteristic number (except as modified in the case of the sex-producing chromosome); and that when fertilization takes place the characteristic number is re-established. The most striking feature of cell division is the longitudinal bisecting of the gene strings (chromosomes) and the provision whereby every offspring cell is granted its full complement of genes, the presence of which is essential to the continuity of life.

The work on the fruit fly (*Drosophila*), done by Professor T. H. Morgan of Columbia University, is chiefly responsible for establishing this theory of heredity. By breeding literally millions of pedigreed flies and observing the results, Morgan and his students have been able to identify the genes responsible for many of the characters which appeared in the adult flies and to prepare diagrams to show the positions of the controlling genes in their respective chromosomes. At one time it was thought that for every character appearing in the adult there is a corresponding gene; that, for example, there is a gene which controls wing shape; one which determines eye colour; another which is responsible for head shape; and so on for all other characters.

The work on the fruit fly and other investigations, however, proved this view to be untenable. It showed, for instance, that red eye colour in this fly is the product of at least fifty genes; that the wing of the fly requires the interaction of hundreds of genes; and that all the other characters are responses in each instance to the influence of many genes. In turn, each gene may affect many characters. Alter a single gene in a co-operative group and the character which is the result of the interaction of the members of the group will be altered.

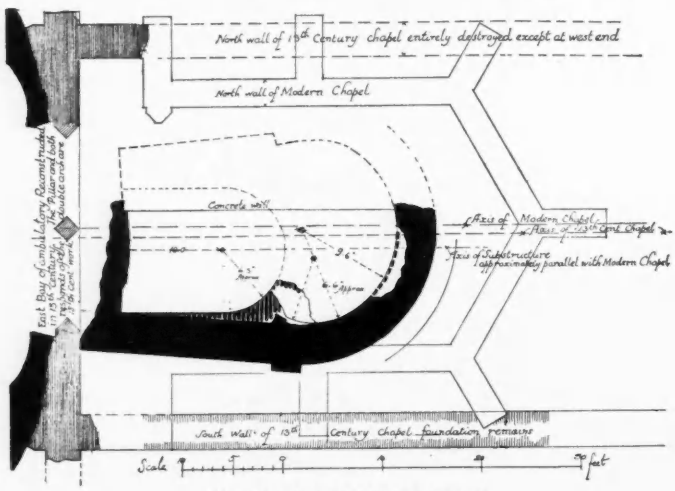
It would seem, therefore, that the explanation of the various ways in which the individuals of a given species develop, whether plant, insect or man, of the peculiarities and diversities that give them individuality, and of the extraordinary resemblances and differences that exist between parent and offspring, requires the assumption that there actually exists a constituent physical entity in the chromosome which is passed from generation to generation and that this is capable of bringing about the development in the new generation of the same character which its progenitors had developed in the parent generation.

Discoveries at Norwich Cathedral.

By the Very Rev. D. H. S. Cranage, Litt.D., F.S.A.
Dean of Norwich.

Excavations for the erection of a war memorial chapel at Norwich Cathedral have revealed the foundations of an early building hitherto unsuspected. The evidence suggests that the foundations are of a seventh century chapel destroyed by the Danes in the ninth century.

THE Cathedral Church of Norwich is remarkable for several features which rarely or never occur elsewhere. Among these the form of the two surviving eastern chapels may be mentioned. They may be described as bulbous in shape, and were clearly a part of the original work of Herbert de Losinga, the bishop of Norwich, who transferred his seat from Thetford to Norwich in 1094. His great church was begun in 1096, and was sufficiently forward for consecration on 24th September, 1101. The northern chapel has been called the Jesus chapel since the end of the fifteenth century, but before it had been the chapel of the Martyrs and later the chapel of St. Stephen. The south chapel is St. Luke's, used since the reign of Elizabeth as a parish church in lieu of St. Mary's in the Marsh, which stood on the south side of the Close and was then pulled down.



SIR CHARLES NICHOLSON'S PLAN.
The dark black line indicates the Norman work. It will be noticed that the south wall leans southwards, so that the chapel was probably horse-shoe in shape.

On the plan of the cathedral there is no sign above ground of a middle eastern chapel comparable with the other two. We know, however, that Losinga built a chapel in which he placed an altar of the Saviour. This chapel was pulled down by Walter de Suffield (bishop 1245-57), and a much larger oblong Lady Chapel built. Our manuscript authority for these statements is the *Registrum Primum*, which was written in the early part of the fourteenth century, and which is one of the most treasured possessions of the cathedral. This, of course, is not contemporary evidence, but there is every indication that considerable parts of it were copied from older documents. The vital passage may be translated as follows :—" He began the work of his church in the place where the chapel of the Blessed Mary now is, almost in the middle of that chapel, and there he made an altar in honour of St. Saviour and placed the first stone in his work."

Of the thirteenth-century chapel there are considerable remains above ground entirely obliterating what was there before. The west ends of the north and south walls remain. The former is of special interest because what looks like a northern buttress has a window jamb in it, indicating that Bishop Suffield had intended to build a square end to the presbytery aisle and do away with the semicircular ambulatory. The east wall appears just above ground and the east end of the south wall. The Norman chapel presumably had an upper story similar to those over the north and south chapels and approached by a wide semicircular arch. When the later chapel was built, four lancets were placed in the upper part of the west wall, of which two still remain. It is true that Corbridge's map of 1727 shows five lancets, but this must be by artist's licence, for there is certainly not room for more than four.

During Dean Lloyd's time (1765-90) a broad pointed window replaced the two middle lancets, with glass painted by Mrs. Lloyd. This glass was placed in the south transept, probably in 1862, and a round-headed window of Norman character inserted. The window still remains, though the glass inserted in it gave place to the present glass some thirty years later. The line of Suffield's gable is still plainly visible above the

window. Below the windows there are two fine arches, ornamented with the dog-tooth, which form the entrance to the thirteenth-century chapel. Curiously enough, the columns and half-columns supporting these arches are not the original ones, but date from the fifteenth century. In the time of Dean Gardiner (1573-89), the chapel was pulled down. It had probably become semi-ruinous, and was felt at that time to be of no great use. The removal of the chapel, of course, necessitated the blocking up of the entering arches and of the quatrefoil above them. In modern times stained glass was put in this quatrefoil, and in the upper part of the arches.

These arches are now revealed in all their beauty after being blocked for three and a half centuries. The mouldings on the east side are, of course, badly worn by long exposure to the weather. The extent of the Lady Chapel was revealed by excavations in 1871. According to the plan in Blomefield's *History of Norfolk*, made in 1743, the graves of Bishop Walter de Suffield and four other bishops were situated in the eastern half of the chapel. No traces of these have been discovered.

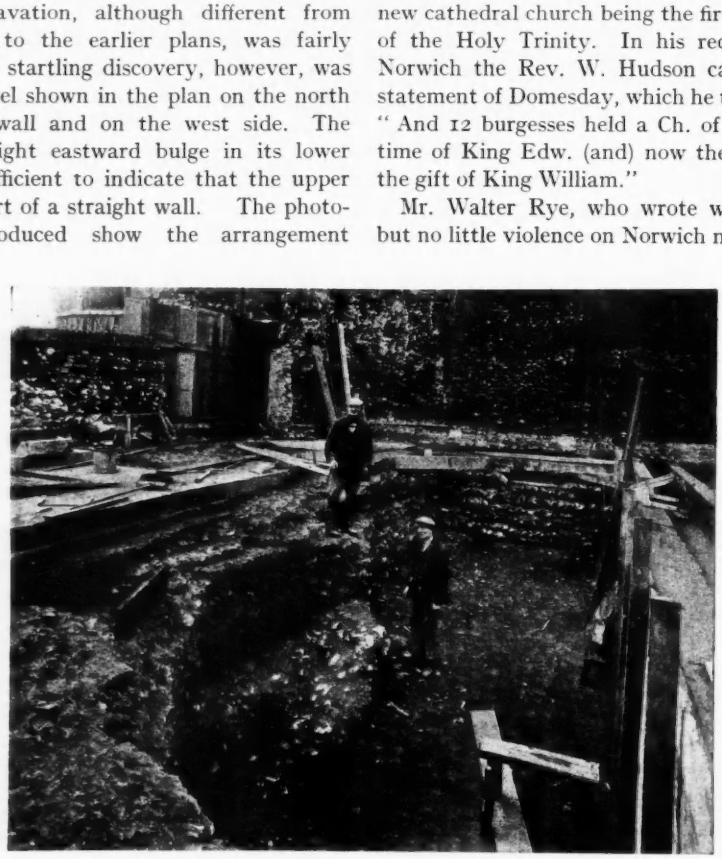
In the autumn of 1930 and the early part of 1931 excavations took place in preparation for the building of a new chapel. They stopped short of the eastern part of Suffield's building, and no undisturbed graves were found. The important question which had to be faced when the digging began was the form of the Norman chapel. A large plan, belonging to the cathedral, which was possibly made for Professor Willis's lecture in 1847, showed a trefoil shape corresponding to some extent with the north and south chapels. This must have been conjectural. Harrod's *Castles and Convents of Norfolk*, published in 1857, has an apsidal chapel without the trefoil arrangement. A plan in the custody of the Dean of Norwich, made by J. Brown, surveyor of the cathedral, probably about the same time, also shows an apsidal chapel with a slight horseshoe bend. Another plan, dating from 1871, goes back to the trefoil shape, and is said to have been the direct result of excavations by B. W. Spaull.

In considering all these plans I was naturally bewildered as to what the true form might be. No doubt the earlier excavators were not able to go deep down, and part of their drawing was evidently conjectural. Sir Charles Nicholson's plan, which is shown

BLOCKED ARCHES LEADING TO DESTROYED LADY CHAPEL.
The arches which originally led to the Lady Chapel are now revealed after being blocked for three and a half centuries.

herewith, was made after very careful examination of all the details. Against the north wall of Suffield's building a few feet of plaster were found, which no doubt indicated the lining of a grave. The north wall of the Norman foundations had been entirely destroyed, but a shapeless lump was found on its site, which had evidently tumbled down from the later wall to the north of it. The interest is really concentrated on the southern half of the excavations. The dark black line shows the Norman work. The curve of the apse is unmistakable, and it will be noticed that the south wall leans southward, so that the chapel was probably horseshoe in shape. On the inner face of the south wall is a slight projection which may have suggested a trefoil shape to the earlier excavators. It seems, however, in fact to be nothing but a support for a column to take an arch at the entrance of the apse. It has an abutment of the ordinary Norman form, i.e., a shallow buttress of considerable breadth.

So far, the excavation, although different from expectation owing to the earlier plans, was fairly straightforward. A startling discovery, however, was made at a lower level shown in the plan on the north side of the south wall and on the west side. The west wall has a slight eastward bulge in its lower courses, but not sufficient to indicate that the upper courses were not part of a straight wall. The photographs here reproduced show the arrangement looking west and east respectively. From these photographs it will be clear that there is the beginning of a small apse at a lower level than the Norman apse, showing a rougher technique in the walling. A careful examination of these walls, as compared with the Norman work near it and with the east side of the Norman foundations of the Jesus chapel, shows that the two works must be assigned to different dates. The upper courses of the older walls correspond with the Norman work, the dividing line between the two being irregular in both the west and south walls.



SITE OF EASTERN CHAPEL, LOOKING WEST.
From these photographs it is clear that there is the beginning of a small apse at a lower level than the Norman apse, showing a rougher technique in the walling.

We are clearly faced with an important new fact in the architectural history of Norwich Cathedral. There must have been an earlier building on this part of the site when Herbert de Losinga laid his foundation stone in 1096. Documentary as well as architectural evidence must be considered.

The first question to face is, was there an earlier ecclesiastical building on the site? In the foundation charter, copied in the *Registrum Primum*, Losinga uses words which may be translated as follows: "For the redemption of my life and the absolution of all my sins I was the first to build at Norwich in honour and in the name of the Holy and Undivided Trinity, a church which I have constructed and consecrated as head and mother church of all the churches of Norfolk." Nothing can be more definite as to the new cathedral church being the first building in honour of the Holy Trinity. In his records of the city of Norwich the Rev. W. Hudson calls attention to the statement of Domesday, which he translates as follows: "And 12 burgesses held a Ch. of Holy Trinity in the time of King Edw. (and) now the Bishop (hath it) of the gift of King William."

Mr. Walter Rye, who wrote with so much ability but no little violence on Norwich matters, thought that the Domesday record convicted the first bishop of lying. This is surely unlikely, and one looks round for another explanation. There is plenty of evidence to show that in the middle ages the church was called Holy Trinity and Christ Church almost indifferently. Mr. Henry Harrod, in his *Castles and Convents of Norfolk*, quotes from Kemble's *Codex Diplo-*

maticus aevi Saxonici, circa 1050, as follows: "And ic an into Nordwich to Cristes kirke iiij. recheren and to into sancte Marian."

Mr. Harrod goes on to quote from the so-called *Chronicle of Croyland*, by Ingulf in 1076, to say that among the monks in that abbey there were fourteen from Christ Church, Norwich. This chronicle is everywhere recognized now as a forgery, but it would look as if there was some tradition of a Christ Church monastery in Norwich. Was this Christ Church, existing some fifty years before the cathedral was founded, on the present site? In this connexion Mr. Hudson again quotes from Domesday: "And the men of the Bishop have 10 houses and in the Bishop's own court 14 *mansure* which King William gave to Aerfast for the principal seat of the Bishopric."

SITE OF EASTERN CHAPEL, LOOKING EAST.

A comparison of the walls shown in the photograph with the Norman work near it shows that the two works must be assigned to different dates. There must have been a building earlier than that of 1096.

Mr. Hudson thought that *mansura* should be translated by some such word as "domicile." In any case we have the remarkable fact that William I gave to Aerfast, last bishop of Elmham, and first bishop of Thetford (1070-85), considerable property in Norwich for the principal seat of his bishopric, even though the actual transfer did not take place till Losinga's time in 1094. All this does not prove that there was a church on the cathedral site, but it makes it not unlikely.

Apart from the documentary evidence, is there any architectural indication besides the recently discovered foundations of an earlier date than 1096? In this connexion it is important to observe the character of the west wall of the cloister. This cloister, in the normal position on the south side of the nave, is the largest monastic cloister in England, and the only one to have an upper story. The western range, as usual, abutted upon it. Most of this range has been pulled down, but its eastern wall, which forms the western wall of the cloister still remains. In it there are several small circular windows splayed both internally and externally. The matter is dealt with in an article by the late Rev. John Gunn in *Norfolk Archaeology*, 1874. It would carry me too far away from my subject to go into all the evidence, but I am certainly inclined to agree with Mr. Gunn that the work is pre-Norman.

Sir Charles Peers and I have made a thorough examination of both sides of the wall, and we are definitely of opinion that the circular windows are earlier than the Norman interlacing arcade above it. If this decision is correct, the question naturally arises as to what the wall was built for. Could it have been part of monastic buildings, claustral or other, of "Christ church" before the time of Losinga? If, for instance, Aerfast began building here soon after the Conquest, the work might well take the form so associated in our minds with pre-Norman work. It is remarkable, however, that in the accounts we have of the foundation of the cathedral there is no mention whatever of previous buildings on the site, though the church of St. Michael in Tombland, and the church of St. Mary in the Marsh, south of the cathedral, are both referred to.

How does all this affect the early foundations at the east end of the cathedral? If a Saxon or very early Norman church, built at the same time as the west wall of the cloister, had been in existence, it would surely be much farther west, where the nave now is. One cannot suppose that a pre-Losingan church would be of anything like the size of the present one. It is difficult for this reason to suppose that Bishop Losinga found a Saxon chapel in being so far east, but if the small apse and the other wall of the period I have already referred to do not represent a

Saxon chapel in being, what are they? The manner in which the Norman apse stands on the earlier work almost proves that the earlier building was already ruined. It is difficult to convey this clearly to any one who is not on the spot, but it is almost certain that nothing was standing above ground when the Norman chapel was built. If, therefore, the early building was a ruin in 1096 when was it anything else?

The History of East Anglia.

Let us remember the ecclesiastical history of this eastern part of England. The original cathedral church of East Anglia was, no doubt, built at Dunwich soon after the foundation of the diocese in 630. St. Peter's, Bradwell-on-Sea, was built by Cedd on the walls of the Roman city of Ythancester about 653, and most of it still remains. The ruined church of South Elmham in Suffolk probably dates from the late seventh century, and some foundations of the cathedral church of North Elmham may possibly be of the same date. These and certainly other small churches must have been built in the seventh century after the Angles and Saxons had been Christianized; 200 years later, in 870, nearly everything was destroyed by the Danes. This is highly probable if not certain.

It seems to me, therefore, that the early foundations we have discovered are those of a seventh-century chapel destroyed by the Danes in the ninth century and never rebuilt. Is there any serious objection to this theory? The only one I can think of is the great thickness of the east wall of the small apse (about eight feet). Saxon apses always had thin walls. It should be remembered, however, that, as the plan shows, there is rather a break about half-way through the wall, and it is not certain that the eastern part has the same masonry as the western. In any case the fact of having a thick footing low down does not necessarily mean that the wall of the apse above ground was thick. Also it is not really impossible that, in this one case, a Saxon apse should have a thick wall.

Is there any other theory which deserves serious consideration? One would dearly like to believe that a little Roman church had been found, but there is no similarity of these foundations with the only ecclesiastical building dating from the Roman occupation which has been discovered, namely, the little church at Silchester, in Hampshire, with its apse at the west end. In Roman secular buildings an apse might be found, especially in the baths, but the bath establishment was a large one, and surely other foundations of it would have been discovered if they had existed. Roman bricks, and at least one roof tile, were found in the walling, but only in those places where they might have been put in 1096. We know, of course, that there were Roman buildings in the neighbourhood, notably at Caistor St. Edmund, where excavations have recently taken place.

A crypt has been formed, so that the discoveries can always be studied on the spot. The excavations have been made possible by the building of the new war memorial chapel, the lines of which are shown on the plan. The idea of such a chapel was conceived by the late Dr. H. C. Beeching, Dean of Norwich from 1911 to 1919. The chapel was to be a memorial, not only of those who fell in the war, but of the preservation of the cathedral itself from hostile attack. For various reasons the completion of the project was delayed, but the chapel is not finished. Great care has been taken not to confuse the history. It will be perfectly possible to trace what has been done from the earliest days to the year 1932, so far as evidence long ago obliterated will allow.

This article is substantially reproduced from my article in *The Antiquaries Journal* of April, 1932, by kind permission of the Society. I am also indebted for help in preparing it, or for illustrations, to various friends, including Sir Charles Peers, Mr. T. D. Atkinson, Dr. F. H. Fairweather, Mr. J. F. Gaymer, Mr. Leslie Hunt, Mr. E. A. Kent, Mr. E. C. Le Grice, Sir Charles Nicholson, and Dr. H. W. Saunders, author of "An Introduction to the Rolls of Norwich Cathedral Priory."

THE MEMORIAL CHAPEL.

It was the excavation for the foundations of the chapel shown in the photograph which led to the discovery which the Dean of Norwich describes.

The Film in Education.

The possibilities of the cinema in education and social progress are discussed in the report of the Commission on Films. Much interest has been aroused by the proposals for the setting up of a national film institute.*

THE term "educational film" is often loosely used to denote many different things. It may be used in a restricted sense for the teaching film, the film in school or in the laboratory serving as an aid to the teacher, to the investigator and to the student; or in a much wider sense for the generally educative or interest film to be shown to larger audiences of children, adolescents or adults. There are subdivisions (for instance, the film for scientific research and the film for historical record), and the two kinds of film shade into each other; but the general distinction remains. There is also the cultural film. For if the film is not only an instrument of visual instruction, it is also a means of entertainment and an art form. But it is in the public cinema that the film has its strongest hold on national interest, and therefore its greatest cultural and social influence, notably on children and adolescents. If the standard of public taste is to be raised, we must begin with the children; and there the public cinema links up again with the school.

Cinematography in Great Britain has endured the neglect of those who control education. For many years most teachers and administrators ignored films. Those who thought about them (with a few notable exceptions) were concerned almost exclusively with attempts to restrict the attendance of children at public cinemas. Educational associations passed (and indeed continue to pass) resolutions deploring the influence of the cinema. Now the cinema is gaining prestige. There is no longer a danger of absolute separation between educated opinion and the production of films. The trade is only waiting, in fact, for an assurance that educators know what films they want, and will use them when they are made.

An Effective Link.

On the success of this partnership depends the future of educational cinematography. If the film is to provide an effective contact between the school and life, the classroom and the factory, the laboratory and industry, then first-class production and first-class projection must be available for the schools. In a system of national education which no longer relies wholly on the printed word, the film becomes an essential instrument in the child's preparation for life.

There are limits to the use of films in school. The ultimate process of education is bound up with the clash of personalities, and the film will be of service just so far as both teachers and children can learn to use it. For that reason it is all the more necessary to study with sympathy and concentration the relation of the cinema to education, in order that it may fit into the school and not sprawl over it. Rationalization involves adjustments which are sometimes painful, before old methods are adapted to the use of new weapons. The influence of the cinema has already found its way into the schools; and the educator has to choose whether he will leave a powerful force unregulated, to do what harm it may, or whether he will admit it as a controlled but lively instrument.

A Vicious Circle.

In the production of educational films there is a vicious circle. A few firms have produced some excellent films and wish to produce more; but producers and teachers are not in touch. Producers do not know the kinds of film which the teachers want, and could not afford to make them for the present restricted market if they did; while such films as are reasonably suitable have perforce been made and edited for general showing. Educational opinion is now aroused, however, and teachers are asking for films to be made to their requirements.

The development of sound reproduction has opened up both new possibilities in the use of the teaching films and new problems. Sound has not superseded the other devices of cinematography; it has merely added an important factor. A well-designed film of this kind is not . . . made with incessant comment, but with picture captions and commentary, balanced and co-operating to produce the clearest and most vivid effect possible. Briefly, sound films are of two kinds, the synchronized film and the post-synchronized. The synchronized is the ordinary sound picture where, if men are depicted working on a coal-face, you not only see their picks but also hear the sound which they make, and where, if explanation is required, it can be given by the man with the pick, demonstrating: "I do so and so . . . "; or by the scientist at work in his laboratory explaining what he is doing. The post-synchronized is a silent picture to which sound has been added, either noises or speech in the form of a commentary. In the latter type the commentator will of course be unseen, but it is easier

* *The Film in National Life.* (Allen & Unwin, 1s.).

to use the usual devices of instructional films: animated plans and models, microphotography and cartoon work generally.

The sound picture is essential if the film is to be used for direct instruction. The voice records the structure of the lesson. A pictorial film has a double reality if the sound of the factory, street or coal mine is represented with the sight. The growth in popularity of the news reel since the introduction of sound is an illustration of this from the public theatre. The affection of those who knew the cinema in the days when the silent film was first unfolding as a new art form is transferred with some reluctance to the sound film. But it is evident that the future production of entertainment films will include sound in its various forms: among them the technique used in "City Lights," where, for almost all the film, sound was no more than a rhythmical background of synchronized music. So little use has been made hitherto in Great Britain of projectors in schools that the future is very nearly open. Development is not weighted in one direction by the recent installation of expensive equipment. It seems, therefore, not only right but inevitable that the schools as a whole should take advantage of the highest technical developments of sound projection.

The Council stresses the need for the establishment of a permanent central organization which will influence the development of cinematography from the point of view of national well-being. The taste of a man is developed during his school days. The cinema is a force which may make or unmake him. Perhaps the greatest service which the cinema can render, as the greatest disservice, is in the schools. It behoves educators to welcome the opportunity of using a new force constructively for teaching and for the development of character and taste. But alone they can do little. They need the active co-operation of enlightened producers, if the best gifts of cinematography are to be available for the schools. A National Film Institute, linking teacher and producer, would promote a piece of distinguished national planning.

Adult Education.

The new visual and aural aids to learning are challenging the long-established dominance of the printed word. The gramophone, the cinema and broadcasting are now recognized as a force in national life, and television will soon be added to the list. Nowhere can they serve us better than in adult education, as mechanical aids to knowledge and enjoyment. This the leaders of the movement have recognized. There are, of course, critics who are always ready to say: "You are claiming too much for the machines, and the use of such aids encourages slipshod work." That the use of mechanical aids encourages slipshod thinking is flatly against the evidence.

Rapid Changes.

Technical schools and colleges are concerned with the application of science to the fundamental industrial and commercial bases of modern civilization, and with the development of a culture which shall be in harmony with the needs and aspirations of the people of a rapidly changing world. For these reasons, those responsible for these institutions are ready to profit by any method of education which can serve these two ends. Many technical institutions are aware of the service that cinematography can render, and have co-operated in its application to educational needs. The instructional aim of technical education makes it necessary to impart precise information in pure and applied science with concrete and definite illustration by experiment and demonstration. The film will clearly become a material help in this process of demonstration, and there is support for this view from the replies of principals of technical schools to a circular letter of enquiry.

The film has been used as an instrument of scientific management in industry. Processes have been filmed to enable the management to study the elimination of waste motions, the co-ordination of movement, and the efficiency of types of machine and of individual workers. An American firm took shots of its workers performing their tasks, and used this to demonstrate to the slower and clumsier how they did an operation badly and how it might be done well. The result is stated to be an increased output of fifty per cent. The International Educational Cinematograph Institute carried out last year an enquiry into the use of the cinema in industrial training and scientific organization in industry throughout the world.

At the other end of the scale the film has been used as a means of guidance in the choice of a career. Little has been attempted in England, but the Institute of Industrial Psychology has made one film with good results and is carrying out further experiments. The reports of European and American experiments are interesting, even if they must be followed with caution. A report from Dusseldorf states: "The knowledge and tastes gained by young people at school may at times lead them to select a trade which proves to be unsuited to their capacities. Cinematography can give a visual knowledge of the requirements of each trade and can, above all, awaken potential tendencies in

the mind of the looker-on. The film is made use of to-day in many centres as a complement to teaching and selection of a trade." A child or adolescent may have only the vaguest conception of the work which he wants to undertake, as is shown, for instance, by candidates for the elementary teaching profession in their reaction to a first teaching trial. In some industrial areas the child leaving an elementary school may pass almost automatically from school to a staple occupation. If the school cinema becomes general, the vocational guidance film could do valuable service.

Recording Research.

The film is a new kind of document for record and research. All history (from the record of the rocks onwards) is ultimately derived from documents, and the most imaginative reconstruction of past events is judged by the test of documentary proofs. The documents to which the student is accustomed, statistics, agreements, " deeds " of all kinds, tell him what was done and when and where, but very seldom how. For the facts as to how anything was done he has been dependent hitherto on verbal narrative, epic and saga, letters and despatches, and written history, latterly made popular by the art of printing; on pictures and drawings, popularized still more recently by mechanical reproductions; and finally on photography, which records situation objectively, and eliminates, in part though never wholly, the selective judgment of the human artist. But the picture and the photograph record only momentary situations or predicament, a cross-section, as it were, of an event or process which takes time to occur. There are, therefore, whole aspects of a past event which, even with the aid of photography, have only been recoverable visually on the stage or in pageantry.

Just as historical narrative transcends mere diagrammatic and statistical record, the documentary film has a function wider than unselective visual record. It perpetuates visually a great historic occasion, a great national calamity or any other non-recurring or unrepeatable event. Films of a great flood may not only be of interest to the geographer, but of value to the engineer. A visual record may aid the student of the future as well as of the past. Historical photographs, though they only go back to about 1840, are already beginning to be appreciated as documents. The film is still too recent to offer examples of such documentation outside recent memory.

The Faraday centenary brought this home. Photographic records of man and of his work began just too late in Faraday's career to present his supreme contribution to knowledge in visual form. Faraday's work in his laboratory had to be reconstructed in a documentary film, with a commentary by Sir William Bragg. Edison, on the other hand, lived just long enough to impersonate himself in the films which present his invention of the phonograph and of other instruments associated with his name. These documents are vivid enough to show that a genuine film would exceed them in dramatic quality by as much as they exceed the still photograph. The film records what really happened (which has been defined as the subject of all history) more accurately than the written notes of an eye-witness, more vividly than a wireless narrative.

The dramatic value to future generations of historical film records is more easily assumed than visualized. The student of to-day does not lament that the news-reel camera was absent from Runnymede when King John signed Magna Carta. He does not think of the Middle Ages in modern terms. But the British student of to-morrow will probably accept the film record of the Treaty of Locarno as a part of the established order—like his fellow to-day. A more general instance are the official film records of the war of 1914-18. No one filmed the defence of the pass at Thermopylae; no one filmed the relief of Vienna by John Sobieski; but episodes of the Battle of the Somme, which may conceivably have for the historian of the future equal interest if not equal importance, were recorded by the official film camera. And the camera recorded not the major tactical moves, but the daily life of the troops, the transport of troops in pre-war London motor buses with boarded windows, a distribution of letters by the post corporal, the men who captured Bapaume warming themselves by a burning building, troops receiving their rations in the line. At sea there were " shots " taken from the deck of H.M.S. *Broke*, the 15-inch guns of the monitors in action at Zeebrugge, the work and crews of the mine-sweepers, and the service of the R.N.A.S.

Primitive Customs.

As in war, so in peace, it is not only the great events which make up history, but the daily life of the nation. It is not sufficient to rely on the accidental selection of the professional producers for the social records of the future. There is much in the life of the changing English countryside which should be deliberately recorded for the student of the future. It is equally important to obtain films of the great mass of local and traditional practices which make up the daily lives of primitive, barbaric and orientally civilized

peoples within the Empire, and to preserve them for future record, before they are overwhelmed by contact with Western customs. It is still possible to obtain such films by an expenditure of labour and time; soon even that will no longer be possible, for the life itself will be gone. Such films would also make for better understanding in the present. There is a growing realization that much which seems obscure in the lives and outlook of a primitive people becomes clear when it is possible to visualize their life and surroundings as they do themselves.

There are two obvious and immediate purposes which the deliberate documentary film may serve: the education of native peoples themselves, and the comparative study at home of racial questions. It is one of the objects of native (as of all other) education to train the faculties of observation, comparison and criticism, so that the pupil may gather experience on which to base his judgment. He is taught to read so that he may meet the needs of the present with the experience of the past. The film literally represents people and events, infinitely widening the range of possible examples of what actually happened. It makes it possible to compare visually a people's own traditional ways and those of other folk, not necessarily European. Differences and contrasts are better observed when they are small and in similar material. The work of African administrators has proved that, in the training of a native people, the most valuable documentary records are films either of themselves or of a race of comparable culture.

To the research worker who is unable to visit his field, the film brings material for comparative study. To the untravelled but interested layman it brings vicarious experience.

The Film in Surgery.

The film has a threefold value in surgery. It records the personal technique of a master, which would otherwise be available only to his immediate disciples. It enables forty students to follow an operation by a master which only four of them in the front row could properly observe, or which was performed as an emergency in their absence. It makes an infallible daily record for the busy man who must otherwise trust his memory. In addition to its more technical uses, the film is a vehicle for transmitting to a lay or semi-skilled audience, in an acceptable form, knowledge which the expert has little time to recast into lectures. Experiments which at present must be arranged and prepared over and over again for each successive audience may be shown with full effect by means of the sound film. This method of instruction can be applied in institutions and communities where expensive apparatus and expert teachers are financially out of reach.

The connecting line running through the report of the Commission on Films is the service which a permanent Film Institute, with sufficient funds and independence of action, might render in promoting the various uses of the film, as a contribution to national well-being. Suggestions are made as to the form which an organization of this kind might take. A film has a national conception, but the film public is essentially international. We have therefore to think internationally in the sense that we want to see the best work from other countries freely admitted into our own.

A Film Institute must be a national organization, both representative and distinctive. But a narrowed and uninformed nationalism, controlling at home a foreign competition with which abroad it is unable to compete, is sterile. Broadcasting, like photography, has done much to break down the barriers between nations; the film can do more than either.

Preserving Historical Apparatus.

LETTERS from Lord Rutherford and other distinguished scientists have recently appeared in the Press, asking for the co-operation of those who possess scientific apparatus likely to be of historical importance. In 1925 the Institute of Physics appointed a committee to advise on the preservation of historical instruments. The committee is anxious to trace any pieces with which fundamental research in physical science has been carried out, and to arrange for their preservation. A catalogue is also being compiled. Several pieces of great historical importance have already been secured for the nation, and are now housed in the Science Museum at South Kensington, and the response to the letters recently published has brought to light several other important pieces. Some articles describing and cataloguing apparatus are published from time to time in the *Journal of Scientific Instruments*.

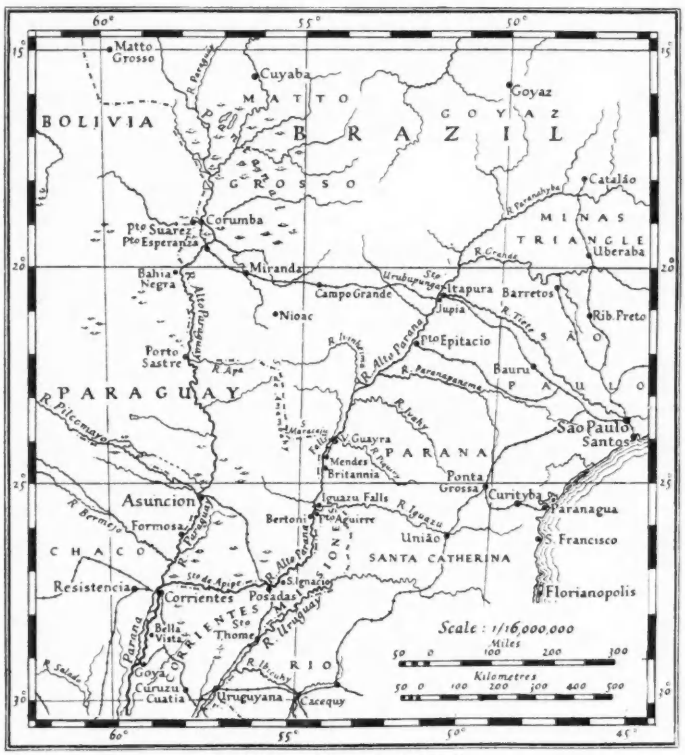
Some of our readers may have such apparatus in their possession or under their charge, and the Secretary of the Institute of Physics, 1 Lowther Gardens, Exhibition Road, London, S.W.7, will be grateful for any information that will assist in tracing such pieces or in completing the catalogue. For the benefit of future historians of physical science it is desirable to have as complete a record as is possible of the work of British physicists, and it is to this end that the task has been undertaken.

The Valley of the Alto Parana.

By W. S. Barclay, F.R.G.S.

The Alto Parana Valley in South America is a little known region rich in rare plant and animal life. A year's research by trained observers would be amply repaid. The author, who knows the country well, stresses the importance of a scientific expedition to this region before the work is rendered impracticable by the advance of civilization.

WITHIN the great valley watered by the Parana River in South America one section is of peculiar interest both to the sportsman and to the naturalist, namely, that of the Alto, or Upper Parana. It begins where direct navigation ceases 850 miles from the River Plate at the Falls of Guayra. Above Guayra Falls river navigation is possible as far as the falls of Uberupongo, which again break the course of the river. In this stretch, some 300 miles in length, the Alto Parana receives five major and at least seven lesser tributaries, making accessible as a whole some 1,000 miles of waterways for vessels drawing from two to three feet draft.



MAP OF THE PARANA VALLEY.

The Alto Parana is thus set like a lake in this great upland basin. On either hand the land rises in varying levels to 2,500 feet and in the north considerably more, while the only outlet is by the Guayra cataracts. A single railway crosses the valley, connecting the coastal uplands of Sao Paulo with those of Matto Grosso and leading eventually with the Paraguay river. But this strategic line hardly touches the primitive life of the valley itself. The same may be said of the river service, which is confined to one small steamer running weekly from the railway crossing down to Guayra, where a town of eight hundred inhabitants faces the lake immediately above the Falls. The only industry here is the extraction of yerba mate, or Paraguayan tea, from the surrounding forest. There is also a sparse cattle industry, entirely confined to the grasslands which throughout this region supplant the forest at about 1,800 feet above sea level.

Below this height, at a level of some 800 feet above the floor of the valley itself, the rainy tropic vegetation spreads like a blanket, forming one of the greatest and most luxuriant forests in the world. The soil is a sandy loam, almost entirely lacking in lime and reddened by the wearing down of the igneous rocks whose successive sheets determine its various levels. The vegetation thus forms a complete contrast to the black-earth soil and marine deposits found in the Paraguay valley and on the Argentine pampas.

Although there is little "big game" in the African sense, in prehistoric times giants existed in South America, as elsewhere. Tusks of the mastodon have been found to the north, in Ceara state, and the giant sloth and the sabre-toothed tiger roamed as far as La Plata, in company with herds of two-toed horses. Ancestors of the present armadillos were as large as an ox. What unknown cycle of events was it which swept this early fauna, including even the horse, from South America with its exuberant vegetation, while semi-arid Africa managed to retain

FISH FROM THE ARAGUAYA.

Types of edible fish caught off Bananal Island in the Araguaya River, weighing from 5 lbs. to 50 lbs. (Photo by Capt. S. C. Bullock.)

her elephants and hippopotami, her giraffes and greater deer and myriad zebra herds? The answer to the riddle has still to be found.

The largest surviving mammal in South America is the tapir, which when full-grown is six feet long, stands over three feet at the shoulder and weighs upwards of 1,000 lbs. A harmless feeder on roots and swamp grasses, its only defence when hunted is to push its long snout, wedge-shaped body and thorn-proof hide through the densest undergrowth on the way to the river—for it is amphibious. The *peccare*, or wild pig, on the other hand, will turn viciously and rend his pursuer, being apparently born with a hatred of every species save its own. It roams the upland forests in bands varying from a score to some hundreds, is about a yard long, lean-flanked, covered with long black bristles and carrying a massive head and shoulders.

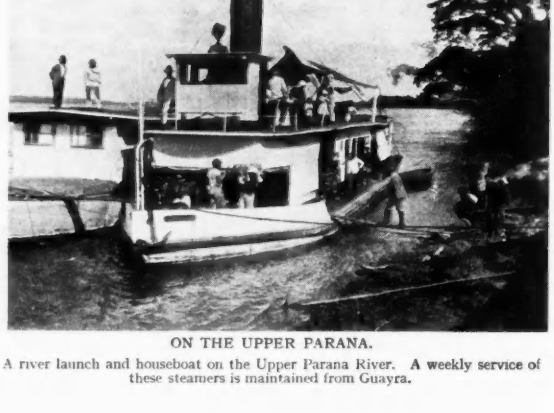
The chief topic in hunting circles in the interior, however, is always the *tigre*, which is no "tiger" but a jaguar. These, like other representatives of the cat tribe, exist in surprising numbers over a very wide range of country, from the limits of the upland grass through the entire forest, along the watercourses, among the swamps, and even venture out to rob the live stock brought up by settlers from the Southern pampas.

The Brazilian forest can reckon over fifty species of monkey, but no baboons or apes. In spite of their numbers it is not easy to catch sight of a troup, for the reason that monkeys seek their food, not in the undergrowth but aloft in the gardens of the tree-tops where, exposed to the sun's rays, most fruits, insects and birds of the forest are massed. The *guariba*, or bearded howler, appropriately named "Mycetes Beelzebub," stands only 32 inches high, and its deep chest is strangely out of keeping. At the other end of the simian scale are the lovable little marmosets, which can be covered by both hands. These tiny, affectionate creatures offer an irresistible temptation to passengers on home-going steamers, but their liability to influenza and chest complaints renders them quite unsuited to our colder clime.

The *irara*, or honey-bear, a possum-like tree dweller some 18 inches long, is well adapted, with long snout, prehensile tail and coarse covering of brown hair, for its task of robbing the nests of the wild black honey bee. These bees, not much larger than a blue-bottle, make their stores within the hollows of lofty trees. The honey is contained in balls of brown wax about the size of a walnut, and is superior in flavour to our domestic honey. The bees are stingless, but their sticky attacks on the passing traveller, possibly for the purpose of obtaining the salts present in human perspiration, are an almost equal inconvenience.

The craving for salt in these red-earth areas is indeed a very marked characteristic of all warm-blooded fauna within the Parana Valley. One hunter at Guayra regularly salts certain convenient patches of open grass within the forest. Once tasted, the news spreads quickly through the animal world, and cattle, deer and all manner of wild things gather regularly, as they might at a drinking pool in the African bush. Occasional "salt-licks" are disclosed in the barrancas, or earthen cliffs, and in such case the earth is literally chewed away till a small cave develops.

The Parana Valley can claim three kinds of armadillos, and the scale descends to as many river and land turtles. The flesh of all is prized as a delicacy, with the exception of the *tatu cavador*, which



ON THE UPPER PARANA.

A river launch and houseboat on the Upper Parana River. A weekly service of these steamers is maintained from Guayra.

is a reputed scavenger. In a region where every morsel of wood or vegetable fibre which does not rot away is chewed into vegetable mould by ants, we may assume the ant-eater to lead a privileged life. He prefers the open meadows, liable to periodic flooding either from rain or river, where in consequence the ants house their colonies in an easily accessible position above ground, using his long sharp claws to tear down the ant-heap walls. When attacked, the animal awaits its foe on its back, with all four paws equally ready to rip and tear; of less apparent value is the long tail covered with horse-like bristles.

Even to the most casual visitor the bird life on these rivers is a perpetual delight. How many of the 1,500 species of birds accredited to Brazil frequent the Alto Parana it is impossible to say, but their numbers are prodigious. As the steamer works its way up-stream from bank to bank we note first the waders, flamingoes, storks and herons, with flights of snow-white egrets stream-lining across our bows. There are gregarious green parrots by the thousand; great macaws and kingfishers waiting to dart from a low overhanging branch into the swirling water. If we are fortunate we catch sight of humming-birds dancing like a flame in the clearings ashore where, contrary to popular belief, they explore the trumpet blossoms on tree and creeper in search of insects, and not of honey. On the sandbanks appear also the *pato real*, or wild muscove duck, the largest as well as the best-eating of its entire race, and here so tame as hardly to move at the sound of a gun. Somewhere in the zenith the eye will always distinguish a hovering hawk, swinging keen-eyed in endless, effortless circles.

No attempt is made here to describe the various edible fish which makes these rivers the fisherman's delight. "There are more varieties of fish in the Amazon," wrote Agazziz, "than in the Atlantic Ocean."

Opportunities for Research.

The Alto Parana Valley, in fact, represents an unspoiled zoo, botanical gardens and acquarium combined. At small cost a houseboat could be built on one of the numerous yerba mate barges, and towed from shore to shore, stream to stream, or sandbank to sandbank as required by the passing steamers. A year's research by trained observers would yield an overflowing harvest, for here is enough new material to stock new sections in every important museum in England and America. It is not worth while to gather this rich, varied and cheap material, before the wild life retreats and the task is rendered doubly difficult by the inevitable advance of civilization.

News by Television

THE transmission of news by television is being investigated by the Marconi Company. The method is quite distinct from photo-telegraphy, and it is believed will meet a commercial need. An account of the process is contributed to the current issue of our contemporary *Television* by Mr. H. M. Dowsett, who is in charge of the investigation.

Up to the present, writes the author, television has attracted the attention of the general public mainly as a new vehicle for entertainment. It has been used as an adjunct to a telephone channel to enable the speaker to view the person with whom he converses, and to this extent it has made a first attempt to meet commercial needs. The commercial applications of television are bound to increase, and there is no question that they only wait on events and opportunity to become self-evident. One point that appealed to the research engineers of the Marconi Company was that if television is to be employed for commercial purposes, it will not always be able to claim a special frequency channel, and the use of the normal commercial wave-lengths and frequency bands would have to be considered. Wave-lengths, for instance, at present in use in telephony may be the only ones available for a particular television service, and the frequency band provided for the telephone channel may have to be accepted for the purpose of television.

The consideration has naturally arisen of how television methods could best be applied to have recognized utility, even if only a very limited frequency band were available. It was evident that a simple black-and-white picture with the black lines sufficiently thick so that definition would not suffer greatly if the edges were not too sharply defined, would be one method of limiting the frequencies necessary for the picture, and to give such a picture interest and value, it should be moving. One such application of television for which a promising future can be foretold is a system of message or "news" transmission. If the type is in a single line, the message can be printed on a tape, and the tape can be fed forwards in a continuous manner.

To convey meaning without it being necessary actually to spell out each word, a sufficient number of letters must be available in the picture for the eye to see at the same time, forming complete syllables even if not words. It is found that with approximately ten letters exposed at once, the eye can conveniently read a television image of plain speech at the rate of 120 words per minute.

Book Reviews.

Archaeology in England and Wales, 1914-1931. By T. D. KENDRICK AND C. F. C. HAWKES. (Methuen. 18*s*.).

In this important book two well-known experts take stock of the present condition of English archaeological studies. It is their business as British Museum officials to keep in close touch with the many specialist researches that are or have been in progress since the war, and to note the innumerable papers that are published on the subject. For the ordinary layman who is interested in archaeology this is, of course, impossible. He will welcome the authors' judicious and attractive summing up of twenty years' work and their considered statements on various controversies, all the more because they give plenty of good illustrations and full references to the literature. Mr. Kendrick treats of the earlier periods from the much debated pre-glacial "eoliths" to the Early and Middle Bronze Age, and of the Anglo-Saxon period, while Mr. Hawkes deals with the Late Bronze Age, the Early Iron Age and Roman Britain—the three periods during which our land slowly but definitely passed from the prehistoric to the historic. On the whole Mr. Kendrick thinks that some "eoliths" at least are of human workmanship. His belief accords at any rate with current estimates of the antiquity of man, whose beginnings are pushed much farther back by the discoveries in the Peking cave and in Central Africa and elsewhere. The Stone Age, old and new, is fully considered, with details of some recent finds that are not generally known—such as the Aurignacian deposit in the Lincolnshire sand-dunes. The flint-mines have a separate chapter after the Neolithic, and so do Stonehenge, "Woodhenge" and other circles whose mysteries are still unsolved. Stonehenge was thoroughly examined in 1919-26 by Colonel Hawley, but its date and purpose remain obscure, though Mr. Kendrick would ascribe its oldest portions to the Early Bronze Age and the later additions to the Iron Age. The Bronze Age in England began roughly about 2,000 B.C. with the arrival of the "Beaker" people on the east coast—people who used bronze and copper knives and pots of a special type and who built round barrows over their dead.

With the Late Bronze Age, from about 1,000 B.C., Mr. Hawkes takes up the tale. It was now, he thinks, that the Celts reached Ireland and migrants both from Spain and from Northern Europe brought new weapons and new forms of civilization. Somewhere about 600 B.C. other immigrants, using iron, came from Central Europe, spreading over the plains but penetrating more slowly into the northern and western hills. The Belgae of Northern Gaul invaded south-eastern England about 75 B.C., twenty years before Caesar came. It is an interesting and well-founded speculation of the author's that these Belgae were Caesar's opponents in Kent and Hertfordshire. Later the Belgae conquered Essex and set up their capital outside the present Colchester, while another body of Belgae invaders established themselves in what is now Hampshire. We are to think of Caractacus, son of Cunobilin, not as a genuine British patriot but as one of those Gaulish invaders whom the natives had no reason to love. Here, at least, is a reason for the peacefulness of Roman Britain after the sharp fighting that followed the occupation of A.D.43 Mr. Hawkes illustrates his excellent chapters with maps of successive invasions and of tribal divisions, and he gives a remarkably clear account of the Roman Wall and its vicissitudes. Finally we have a judicious chapter by Mr. Kendrick on the Anglo-Saxon period, giving cautious support to Mr. Leed's theory that the Saxons invaded from the Wash and thence reached the Upper Thames, and suggesting that, as in France at a later period, the early invaders sailed up the rivers and made temporary settlements. Late in the fifth century the Britons seem to have driven such pirates away, but new bands in the sixth century made good their footing. We are glad to find that Mr. Kendrick calls attention to Dr. Nils Aberg's "The Anglo-Saxons in England" among other recent foreign studies of this period. Dr. Aberg's careful examination of Anglo-Saxon brooches and comparison of them with Continental examples form an illuminating piece of true archaeological research.

The Biology of Spiders. With Special Reference to the Danish Fauna. By E. NIELSEN. II Vols. (Williams & Norgate. 30*s*.).

Volume I of this work is a somewhat abridged translation into English of Volume II, which is really Nielsen's "De Danske Edderkoppers Biologi," with some additional observations from other parts of Europe. This form has been adopted, partly to make the work accessible to the world in general, partly to provide the illustrations in the second part, which are as profuse as they are good. Major Hingston has told us in a work recently reviewed in these pages that spiders which he observed in British Guiana have not the intelligence to repair their damaged webs. But they are certainly highly endowed animals, with several very striking faculties and remarkable characteristics. The most familiar and striking is that of spinning, which is used for surprisingly varied uses. The best known is for snares, of which the author notes six types, but also for temporary refuges, for homes during hibernation, and during moultings, to make their cocoons, and for their protection, for sperm-webs, for the "securing-thread" by which the spider keeps physically attached to his base, for bridge-threads, for nets for tying up their prey, for viscid lassoes for hunting, and finally for gossamer. The latter, combined with the securing-thread, gives them almost as much mobility as though they were winged, for with it they can transport themselves through the air, under favourable conditions. They do it by paying out a length of thread until it is sufficiently buoyant to give them support in the air, when they can float down wind; although, of course, they have no control over the direction, they can drop to the ground when they wish by hauling in the thread and so reducing buoyancy. In this manner they can travel incredible distances, and have been recorded two hundred miles out to sea. Moreover, McCook records the fact that one species at least, *Sarotes venatorius*, Linn., is common to the eastern coast of North America and the west coast of Africa, a distribution no doubt due to the trade winds.

Fertilization is actually effected by the application, not of the genital organs of the male, but of his palpi. It is widely believed even among professed naturalists, that the male spider carries his devotion to such extreme length that he supplies the female with a meal *in corpore vili*, as the price of matrimony. We are told that this view is much exaggerated, although there is a definite element of danger, more particularly in *Epeira*, the common banded spider of our gardens, in which the female appears to be particularly voracious, so that the male has to exercise special caution and activity to escape paying for his embrace with his life. It appears that this is only a matter of hunger, and that a well-fed female is safe enough, although even the most ferocious *Epeira* is capable of being coaxed into a moment of weakness which is, however, fleeting. A remarkable result of this element of danger is that male spiders will take

possession of immature females and wait until they are adult, the idea being, apparently, that in the teneral state after ecdysis, the female is not only helpless but harmless. It is not generally known that there are venomous spiders which are very dangerous, though they are not recorded, apparently, from the continent of Europe. The nearest is the *malmignatte* of Corsica, but its congener *Lathrodectus lugubris*, Koebert, dreaded by the Tartar under the name of *karakurt*, is capable of inflicting a bite that is not only extremely painful, but may leave a man permanently injured, or even be fatal.

The name of the translator is not given. The work has been well done, in spite of its technical character, though the alien hand can be detected. It is a pity, however, that a serious zoological work should commit the vulgar error of calling spiders insects, which is not a matter of translation, but of definition.

The Evolution of Human Behaviour. By CARL J. WARDEN. (Macmillan. 15*s*.).

Professor Warden of Columbia University is a psychologist and therefore endeavours, in his interesting and thoughtful account of the evolution of man, to lay stress on behaviour rather than on bodily structure. For lack of evidence the attempt, it must be confessed, is not very successful. But the critical chapter, "When Anthropoid Became Human," gives a much more plausible account than is usually given in such books of the very slow, very gradual, but immensely significant change from the animal to the man. The explanation is at best hypothetical; the Christian belief in a divine creation of man with a soul is in no wise shaken by these elaborate guesses at truth. Still, Professor Warden's insistence on the antiquity of the human race in its most primitive forms is valuable. It is too often forgotten that the historic period is but a trivial part of the long ages during which man has lived on the earth.

The author's compact account of "The Coming of Modern Man" is carefully written, but raises anew the doubt whether the foundations of pre-history have yet been well and truly laid. Research the world over is adding so much new material every month or so that it is unsafe to be dogmatic about the origins of the race. Professor Warden looks to Central Asia as the fountain-head, but recent finds in Central Africa, South Africa, Palestine and elsewhere have now to be seriously considered, and Professor Elliot Smith, for all that the author says against his theory, may well be right in looking to tropical Africa as man's first home—his Garden of Eden, to adopt the language of Genesis.

In his closing chapters Professor Warden deals with "Race and Civilization" and with "Present Trends in Evolution." It is refreshing to find an American scientist protesting against the arrogant and fantastic theories of racial superiority which exalt the "Nordic" to a pinnacle and relegate the negro to the level of the beasts. The truth is, of course, that the three main stocks of the Western world are now so inextricably mingled that the "hundred per cent Nordic" is as rare as the dodo, while "no definite and certain evidence of racial differences in intelligence has been obtained up to the present." Environment and opportunity count for infinitely more than race. The same forces are constantly at work on modern man, whose evolution has by no means ceased. The author's cautious discussion of the tendencies to be observed to-day is well worth reading. He emphasizes the regrettable effects of modern war in which the strongest perish whereas in the wars of the ancients the strongest presumably survived. And he is wisely sceptical in regard to such theories as Spengler's, for there is no assurance that history will repeat itself and that the great nations of the present day will necessarily decline and pass away as did the Empires of the past. The wisest of us can only speculate about the future, and most of our speculations will be wrong.

The Italian Expedition to the Himalaya. By FILIPPO DE FILIPPI. With Chapters by G. DAINELLI AND J.A. STRANGER. (Arnold. 50*s*.).

The de Filippi Expedition over the Himalaya and the deadly Karakoram to Chinese and Russian Turkestan was described in Italian eight years ago. At last the English narrative has appeared, in sumptuous form, illustrated with two coloured plates, fifteen panoramas, four coloured maps and over three hundred photographs. The scientific results have been dealt with in detail by specialists in ten volumes, of which six have already appeared. The achievement is impressive. They established fourteen gravi-metrical stations to connect up the network of the Indian Survey with the Russian Military Geographical Service stations in Ferghana and the Pamirs. They found that the gravity values are generally in excess in the Himalaya and Karakoram and in defect to the south and north of them. A complete series of magnetic observations was also taken. A long series of barometrical and hypsometrical observations have resulted in a mass of new data; three sets of meteorological and aerological observations were made at very different stations and a great deal of astronomical-geodetic and topographical survey work.

Professor Dainelli devoted himself to geology and anthropology. He was constantly engaged in independent expeditions exploring Baltistan and the whole of Ladak. He collected eight hundred specimens of minerals and several cases of fossils, showing a series from the Ordovician to the Eocene. He made a collection of plants over 16,000 feet, and of a few fishes from the Indus, though zoology was the least favoured science. About four hundred and fifty systematic anthropological measurements were taken and a quantity of studies, sketches and observations; six different stocks of man are classified, including a new one, the Purig. He dealt in detail with ethic, religious and philological distribution, family and social organization and the displacement of populations. He has given also detailed study to the problems of glaciation on the roof of the world and shows two periods of uplift in the Quaternary.

The scale of the expedition was tremendous, and it is no wonder that the poverty-stricken natives of Baltistan and Ladak met them with passive resistance and refused to provide transport until persuaded that it was not war! The immense hardships involved in conducting scientific work encamped at 18,000 feet, are merely hinted at. The author is a resourceful leader, who conducted his great expedition through enormous difficulties without thrill or *contretemps*. He is also a good writer, for he has given us an extremely readable and absorbing travel book and the illustrations are lavish. There is no lack of human interest. The book is a credit to all concerned. The translator, Mr. H. T. Lowe-Porter, hides his light in a note, without which no reader would guess that it was not originally written in English.

In the Footsteps of the Buddha. By RENE GOUSSET. (Routledge. 15*s*.).

In effect this is a book about a book. It follows, as summary and commentary combined, the narrative of the travels from China to Bengal and back of the great Chinese pilgrim, Hsuen

Tsang, in the first half of the seventh century of our era. The life and travels of this Buddhist monk have been translated into both English and French; but they are not as well known as they deserve. For those who are not already acquainted with them, M. Gousset's book, which has been excellently translated, will serve as a most informative introduction. In addition to following the original narrative, the author enlarges on his text in the light of recent archæological and geographical research. As we journey here with Hsuen Tsang among the oases of Central Asia—through Eastern Turkestan, Samarkand, Balkh and Gandhara to the Holy Places of ancient India, we may learn from the investigations of Sir Aurel Stein, von le Coq, and other explorers, who have rescued from cities long buried in the desert sand paintings in which we may actually see how these people looked and dressed when Hsuen Tsang visited them shortly before they were to succumb to Turkish hordes.

The object of Hsuen Tsang's journey was to learn the true doctrine of Buddhist philosophy. Buddhism, which spread over the greater part of Central and Eastern Asia as a result of the missionary zeal of the Indian Emperor Asoka, reached China, according to tradition, in the first century A.D.; but the teaching as known in China in the seventh century contained many discrepancies, and even adsurdities, which Hsuen Tsang hoped to resolve by visiting the Holy Places of Buddhism, following in the footsteps of the Buddha, and by bringing back copies of the sacred writings to China. In 629 A.D. he left Ch'ang-an, the modern Si-an-fu, the capital of the great T'ang dynasty, which had established itself not long before. He did not return until 645 A.D. Although he left China against the express command of the emperor, the great T'ai-Tsung, on his return he received immediate and signal recognition for his achievement. In the following year he produced the narrative of his travels and spent the remainder of his life translating from Sanscrit into Chinese the large number of manuscripts he had brought from India. He died in 664 at the age of sixty-two.

The passing of time has but added to the value of these records of early Buddhist travel; while the archaeological exploration of Central Asia enhances continually the significance of the detail which Hsuen Tsang and those who preceded or followed him have set down in their narratives. Hsuen Tsang failed to reach Ceylon owing to the disturbed state of the island at the time; but he left no site in India connected with Buddha unvisited. Vivid as his account of India may be, and although he describes social, political and religious conditions which were soon to pass away under the assaults of Hinduism and of invasion from outside, yet it pales in interest beside his account of peoples who, we have learned only recently to the surprise of scholars, spoke an Aryan tongue of the western group of Aryan languages Shortly afterwards they were overwhelmed by the Turk to remain entirely unknown until their existence was once more to be brought to light in the present century by the spade of the archaeologist.

A Cotswold Book. By H. W. TIMPERLEY. Drawings by L. S. LOWRY. (Cape. 8*s*. 6*d*.).

Mr. Timperley is one of those wise people who, though they may seem eccentric in this age of whirring wheels, still walk. "Wise," because he knows that it is only on foot that you can really understand the Cotswold—or any other—country. He has himself what he terms "imaginative perception . . . the clairvoyant state of mind arising from deep foundations of knowledge as well as perfectly attuned sympathies, in which men like W. H. Hudson have found their greatest happiness and done their best work." He loves the quietness and serenity of the uplands, with their ancient trackways, camps and barrows, and knows the exaltation of spirit awakened by the spaciousness of their wide and windy skies and limitless horizons. He has a delicate and thorough appreciation of Cotswold stone, and of its proper use, which combines "human skill and natural loveliness." One of the best of his chapters describes his first approach to Chipping Campden. "It appeared suddenly, and for a minute or two the silver-grey radiance of its rain-drenched roofs taking the sun kept me entranced . . . as though I had looked at loveliness beyond the bounds of earthly joy. The memory exalts me yet."

The author knows how to enjoy birds. "The secret is," he says, "to keep an unjaded interest in all birds, and let the glimpses of rare ones come to you as greater joys among lesser, not as sudden excitements punctuating flat days." These words are true and might well be taken to heart by the type of ornithologist who spends his time scouring the countryside for *rarae aves*.

It is perhaps ungracious to find fault with a book which has given us so much pleasure, but we must confess that we sometimes found a certain sameness in Mr. Timperley's descriptions. His enjoyment of Nature is so intense that every scene evokes a rhapsody; such a temperamental response almost inevitably produces repetition. But there is hardly a page which does not contain some phrase which attracts by its intimate perception of elusive beauty. Though this volume is no humdrum guide-book it would be improved by the addition of a map with thumb-nail sketches of the features—church towers, barrows or camps—which the author describes. And an index is regrettably omitted.

Some of Mr. Lowry's drawings succeed in interpreting the author's moods.

The Archaeology of Cornwall and Scilly. By H. O'NEILL HENCKEN. (Methuen. 10*s*. 6*d*.).

The new volume of the "County Archaeologies" is remarkable even in this excellent series for the fresh and thorough scholarship that Dr. Hencken displays. He is the first to describe the many chambered tombs in Scilly—thrice as numerous as the similar prehistoric graves in all Cornwall—and he discusses in an interesting fashion the classical and old Celtic legends of sacred islands or islands of the dead which have some connection with these strange Scillonian megaliths. Cornwall even in the Stone Age had relations with Brittany, and through the Bronze and Iron Ages it was trading with Western France and Spain on the one hand and Ireland on the other, as finds of Irish gold and Mediterranean coins and other articles abundantly testify.

To the prehistoric tin trade Dr. Hencken devotes a most valuable chapter. There is an ancient trackway across the narrow isthmus from Hayle to Marazion, by which Irish merchants came to traffic for the tin stored on St. Michael's Mount. The author uses the evidence of the lives of early Celtic saints like St. Samson as well as that of finds to bring out the importance of this route, which avoided the perils of the voyage round Land's End. The Romans paid little attention to Cornwall: their ships took tin away, in the third century, but they did not build roads to connect this remote region with the rest of Britain. When the Romans departed, the Cornishmen long maintained their independence against Saxon incursions, protected by their moors and their poverty as much as by their valour.

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